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INSTRUMENTS

INDUSTRIAL — SCIENTIFIC

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Devoted to Measurement and Control Problems

Vol. 2. No. 11 Pittsburgh, Pa. November, 1929

NOV 27 1929

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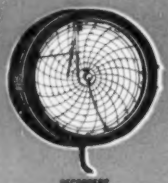
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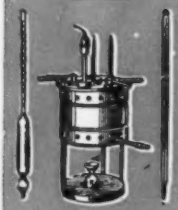
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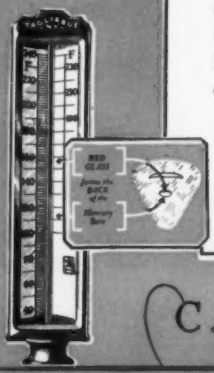

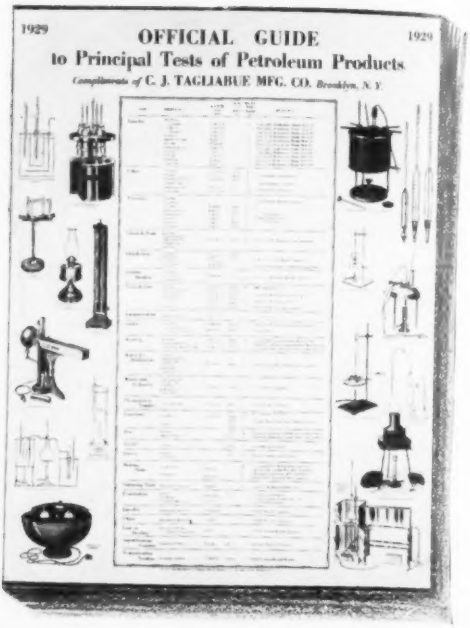
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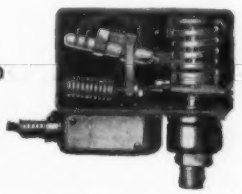

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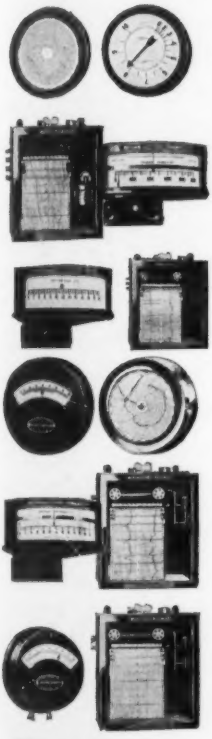

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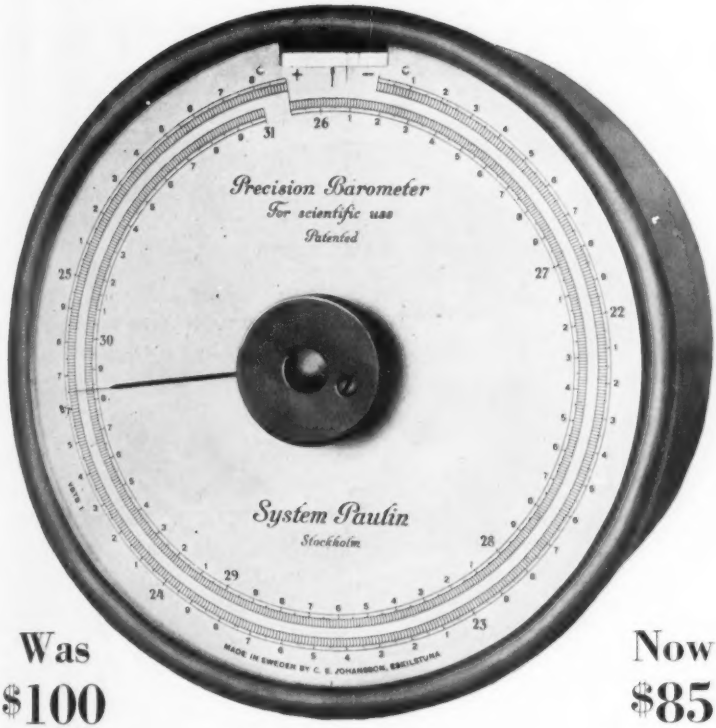

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Published the 15th of each month by

INSTRUMENTS PUBLISHING COMPANY

1117 WOLFENDALE STREET, PITTSBURGH, PA.

JOSEPH J. VIGNEAU, *President* RICHARD RIMBACH, *Vice-Pres. & Treasurer*

TERMS OF SUBSCRIPTION
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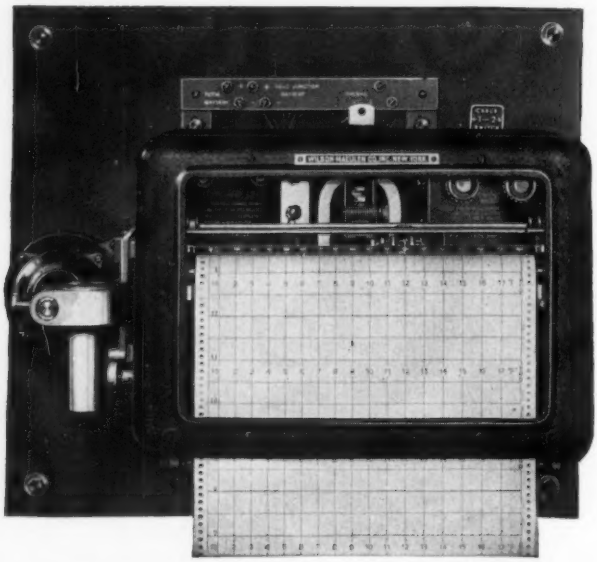

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Vol. 2, No. 11 NOVEMBER, 1929 Pittsburgh, Pa.

To Our Readers

WITH the December issue, INSTRUMENTS will have completed its second year. During this short period it has made a very definite place for itself.

The Reader's Service Department has shown the largest increase in services given. During the first 12 months about 30 questions a month were received on sources of supply of certain instruments and measuring devices. The first 6 months of this year the same number of inquiries were received as in the whole of 1928. Inquiries received during July, August and September totaled 272 and during October 120. That is, at present we are receiving in a single month almost half the number of inquiries received during the whole of the year 1928.

You will appreciate the vast amount of preparation required to have our files in order, so that the large amount of information can be taken care of, without delay.

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——— :: ———

Differences of Opinion

THE editor is always very glad to have the readers write in on any subject pertaining to measurement in which they have a special interest. Also, on anything appearing on the pages of this publication. If such opinions differ from those expressed in print they are doubly welcome—but, the editor feels that it does not necessarily follow that what was printed was a mistake.

Some time ago I happened upon a quotation of which I had a copy made and placed under the glass on my desk. This is given here.

"When a plumber makes a mistake, he charges twice for it. When a lawyer makes a mistake, it is just what he wanted, because he has a chance to try the case all over again. When a doctor makes a mistake, he buries it. When a judge makes a mistake, it becomes the law of the land. When a preacher makes a mistake, nobody knows the difference. But when the editor makes a mistake—GOOD NIGHT!"

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Indicating Frequency Meters

*B. W. St. Clair**

THE general interconnection of large power systems has made necessary frequency indicating devices of high sensitivity and dependability. To get the required sensitivity without sacrifice of desirable electrical characteristics has necessitated the development of a new form of electrical indicating instrument of "ratio" type. A brief review of the more salient points of frequency meter design is given here.

Aside from the resonant reed type of indicator most frequency meters have been devices to indicate the ratio of two currents, i.e., the ratio of two impedances, one or both of which were frequency sensitive. The necessity for indications that are independent of voltage makes necessary this ratio measurement. A single circuit that is frequency sensitive while useful for laboratory purposes is obviously of no use in practice as the current will vary with voltage as well as with frequency. There are a number of circuits that may be used for various purposes. Some of them are discussed here.

The simplest pair of circuits is that shown in Figure 1. The current in A branch will not vary with frequency. The current in B branch of the circuit will decrease with frequency, and if the inductance L is very large compared with the resistance of this circuit the current will vary substantially inversely as the frequency. As a certain amount of resistance is necessary in the indicator itself and in the inductance coil this condition can never be realized and the current varies less rapidly than the reciprocal of the frequency. This means that the rate of change of ratio of currents in A and B circuits is small and the sensitivity of the device is thus small.

This circuit has another disadvantage in that the current in B circuit will depend to some extent upon the wave shape of the applied voltage. The impedance to the third harmonic will tend to be three times the impedance of the fundamental and the impedance to the fifth harmonic five times that of the fundamental. This means that the tendency is to minimize harmonics in the current in B circuit whereas they are not changed in A circuit. This will introduce errors in the indications of the indicator when the voltage deviates perceptably from sinusoidal.

A circuit that is akin to this one and in use at times is that shown in Figure 2. In this circuit a capacitance is used in circuit A instead of the inductance used in circuit B of Figure 1. This combination has substantially the same properties as that in Figure 1 except that the current in Branch A tends to vary with the frequency instead of with the reciprocal of the frequency. This combination is also subject to objections on the score of wave form troubles. The impedance of Branch B to the various harmonics tends to vary as the reciprocal of the order of the harmonics. Thus the impedance to the third harmonic is one third that of the fundamental and three times normal third harmonic current flows. The ratio of the currents in branch circuits A and B thus varies with the wave shape of the applied voltage.

*Standardizing Laboratory, General Electric Company.

This second group of circuits has one practical advantage over those of Figure 1 in that it may tend to introduce less voltage error into the final indications. The inductance in branch B of Figure 1 must be iron clad in order to get sufficient low resistance. The flux density therefore influences the value of the inductance and the circuit therefore has some change of constants with voltage. However, this is not generally serious.

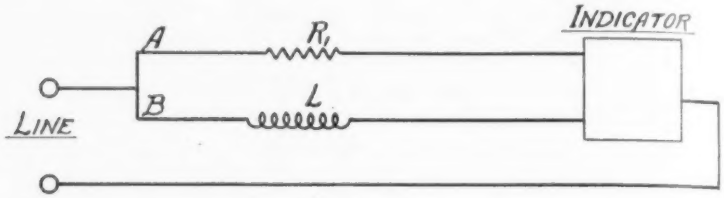

Fig. 1.

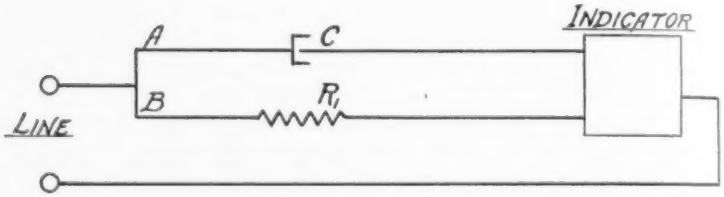

Fig. 2.

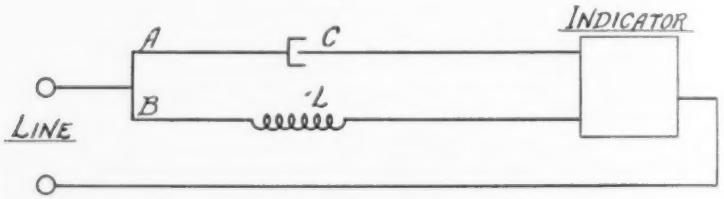

Fig. 3.

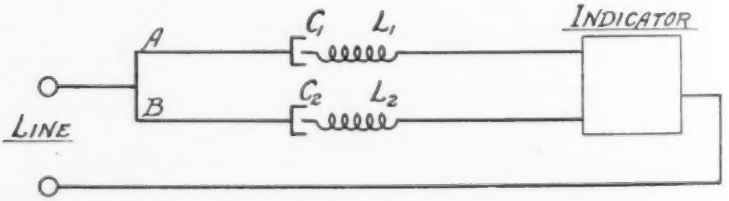

Fig. 4.

A modification of the two previous circuits can also be used. This combination is shown in Figure 3. The change of ratio of currents in branch A and B will be much more rapid than in either Figure 1 or Figure 2 since the impedance of B increases with frequency and A decreases with frequency. This circuit, however, is very subject to wave form disturbances since the harmonics in B are suppressed by the choking action of L and are enhanced in circuit A by the action of capacitance C.

FIG. 5.
CONSTANTS OF CIRCUITS
A
B
Resistance (Ohms) 350 845
Inductance (Henries) 7.0 7.0
Capacitance (MFDs.) 1.0 1.0
AMPERES
CYCLES
FIG. 6.
CONSTANTS OF CIRCUITS
A
B
Resistance (Ohms) 350 270
Inductance (Henries) 6.7 4.1
Capacitance (MFDs.) 2.0 1.0
IN PHASE COMPONENTS
AMPERES
FIG. 7.
CONSTANTS OF CIRCUITS
A
B
Resistance (Ohms) 350 270
Inductance (Henries) 6.7 4.1
Capacitance (MFDs.) 2.0 1.0
FUNDAMENTAL
3rd HARMONIC
IN PHASE COMPONENTS
AMPERES
CYCLES

In making frequency meters of large range either the circuits of Figure 1 or 2 may be used. Long range indications are understood as those of 20 to 70 cycles, of 15 to 90 cycles and the like.

Short range instruments as 55 to 65 cycles or 59.5 to 60.5 cycles require circuits that change much more rapidly with frequency than any of these three. A very effective set of circuits was described by Mr. W. H. Pratt and Mr. D. R. Price in Journal A.I.E.E., 1912.

This circuit in its most effective form makes use of two resonant circuits as is shown in Figure 4. The general features of resonant circuits are shown in Figure 5. The resonant points of branch circuit A and B are different. One circuit is resonant at a frequency below the lowest scale value of the instrument and the other is resonant at a value above the highest scale value. This is shown in Figure 6. It is seen in this figure that the current in A branch decreases as the frequency rises and in B branch increases with rising frequency. These rates of change in practice are very rapid.

This combination of circuits is very free of wave form troubles. These highly resonant circuits act as wave filters to pass only the fundamental. They have very high impedance to the high harmonics as can be seen in Figure 7.

Despite the fact that the current wave shape in each circuit is different from its voltage (except when the voltage is sinusoidal) there is no error introduced as the filtering action is the same in both circuits and the current that passes is almost purely fundamental.

The usual way of constructing "ratio" instrument elements has been to use two armature coils upon a common shaft. The armature coils are at an angle to each other. A photograph of such an armature is shown in Figure 8. A diagrammatic representation is shown in Figure 9.

The action of these can be shown by the vectors in Figure 9. The vector resultant of fields A and B will align itself with F—the direction of the field from the field coil. As the frequency increases the current in A will decrease and the current in B increase. The length of the vectors in Figure 9 will then change and the resultant R will therefore shift its space phase position and will thus cause the armature to take a new position to align R parallel with the field of the field coils. This is, of course, a very elementary treatment. No attention has been paid to relative phase angles in these three circuits. Figure 10 shows vectors for 55 cycles, 60 cycles and 65 cycles.

This form of indicator when used with the two resonant circuits is very effective for relatively short scale ranges as 55 to 65 cycles, but does not have sufficient sensitivity to give accurate indications where very high sensitivity as a 59.5 to 60.5 cycle scale is required.

A form of indicator of better torque producing properties has been worked up and described by T. A. Rich at District 1 A.I.E.E. Student Convention in Troy, May, 1929. This indicator has several advantages as a "ratio" instrument. The principle is applicable to numerous types of indicators where ratios of currents, voltages or impedances must be indicated. The general form of this indicator is shown in Figures 11, 12 and 13. For the sake of clearness in presentation it is first developed as a ratio instrument for d-c. circuits. The torque producing element is first

developed. The general circuit of the torque element is shown in Figure 11.

There are two field windings, F_A and F_B which are equal and interwound and of opposite polarity. There is a single armature winding which carries the sum of the currents in A and B. Assume that this device is used on direct current. The field flux from the field coils will

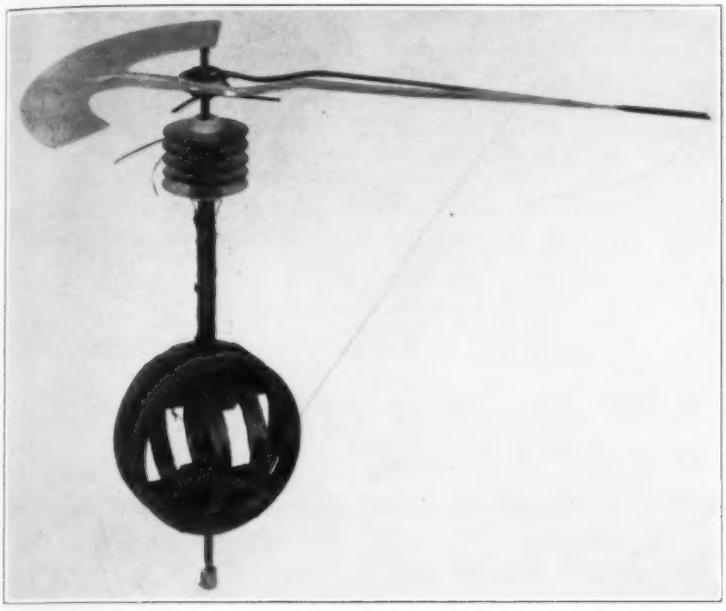

Fig. 8

be proportional to the difference of the currents in circuit A and circuit B. The flux from the armature is obviously proportional to the sum of currents in A and B since the armature is common to both circuits. The torque or turning tendency of the armature is proportional to the product of the flux in the field coils and the armature (assume the armature is at right angles to the field coils). Then the torque produced is proportional to the product of the sum and difference of the currents in the two field coils. This introduction of the difference of two currents in the final torque equation is responsible for the very high sensitivity possible in this instrument. The difference of two currents which are almost equal will vary very rapidly with relatively slow changes in the currents themselves. A typical result is shown in the table below.

A (milliamperes)	B (milliamperes)	A—B (milliamperes)	A+B (milliamperes)	(A+B)×(A—B)
19	20	—1	39	—39

Assume a 5% change in A and B, one going up and one going down.

18	21	—3	39	—117

As the torque is proportional to the product of the sum and differences the torque is here shown changed by a factor of three when the currents

have changed 5%. The minus sign indicates that the turning moment is toward the low side of the scale. A plus sign in the difference would indicate an up-scale torque. As the instrument now stands the pointer would throw to one side or the other but would not take up a definite position on the scale. The torque would vary but the scale indication would not. It is obvious that some control element is necessary to cause a balanced position of the pointer. This element must provide a control torque that varies with the square of the voltage as the torque itself will vary with the square of the voltage. A control torque whose voltage variation is other than the square of the voltage will introduce voltage errors into the indications. This element could be introduced in several ways.

The most simple way is to add another torque producing device to the armature and to arrange this device to produce a torque tending to set the armature at right angles to the field coils. A piece of magnetic material whose plane is parallel to the plane of the armature coil will produce such a torque. Its action can be seen in Figure 12.

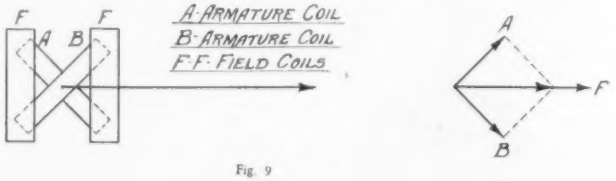

Fig. 9

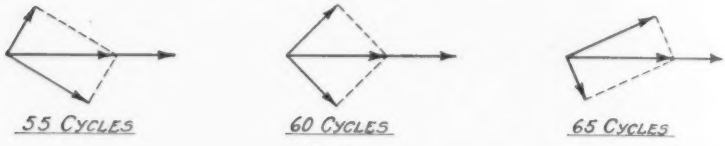

Fig. 10

Fig. 11

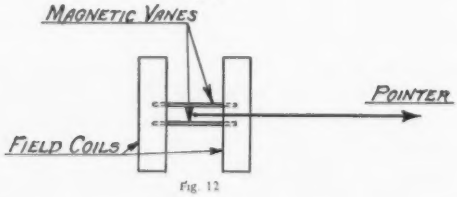

Fig. 12

In this figure no armature coils are shown. If the pointer is moved from the center scale position the magnetic vane tending to parallel itself with the field of the field coils will produce a torque tending to return the armature.

If now this magnetic vane be added to the armature the action will be the same as before and no complications are introduced by its addition

to the armature. Its plane being parallel to the plane of the armature coils the armature flux threads it at right angles to its length and there is not longitudinal magnetizing of it by the armature current.

The reaction of the armature and the field coils will tend to deflect the armature away from center scale position.

The reaction of the armature magnetic vane and the field coil opposes this and a balance point is thus reached where the two tendencies are equal. The device thus becomes a very sensitive indication of equality or lack of equality of two circuits.

If this type of indication be added to the double resonant circuit illustrated in Figures 4 and 6 it becomes a most sensitive indicator of frequency. The action on a-c. is the same as the action on d-c. as described above. There are, however, other properties when used with these resonant circuits that cannot be dealt with here. It is very feasible to build instruments whose full scale deflection (90°) takes place when the frequency changes from 59.5 to 60.5 cycles. If it were possible to produce inductors and capacitors of sufficient constancy it would be feasible to build instruments of 59.9 to 60.1 cycles scale rating.

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INSTRUMENTS BOOK SHELF

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APPLIED INORGANIC ANALYSIS. *Dr. W. F. Hillebrand and Dr. G. E. F. Lundell.* John Wiley & Sons, Inc., New York, 1929. Cloth 5½ x 9 inches, 929 pp. Price, $8.50.

REVIEWED BY ARTHUR SHRODER

This book reflects the tendencies of the present-day chemist to revert to the painstaking analyses of the last decade for the greater accuracy demanded by modern methods of testing materials, but in doing so, to take advantage of the new labor-saving laboratory apparatus, new mechanical aids for saving time, the new theories of hydrogen ion concentration, solubilities, new chemical reagents of higher degrees of purity, colormetric, nephlomotric, spectrographic and electrolytic methods of analysis.

It is somewhat novel in its treatment of the subject. One might expect from its title that it contained a series of specific methods for the analysis of the various materials of commerce. Instead of this, it treats of the general principles underlying "the quantitative preparation of a compound, or solution, that contains nothing that is not taken care of in the calculation on which the determination is based."

The procedures recommended are based on the life-long experience with rock and mineral analyses of Dr. Hillebrand and the researches of Dr. Lundell and his coworkers on the analysis of the standard analyzed samples of the U. S. Bureau of Standards. Numerous tables of physical constants, results of analyses, descriptions of instruments and apparatus are found throughout the text.

It is divided into four parts. Part I deals with the physical equipment, apparatus and reagents for the tests and a detailed description of the technic of analysis. Part II treats of the actual methods and technic to be used in determining the various chemical elements, including many of those rarer elements which are just coming into commercial importance. Parts III, IV and V treat of the analysis of silicate and carbonate rocks, glass and refractories. The indexing, author and subject, is very good.

The book is essentially a compilation of the methods of analysis as published by the U. S. Geological Survey and the U. S. Bureau of Standards, but does contain many new facts. Its detailed and almost encyclopoedic treatment of the subjects covered, warrant the book being made the nucleus of a library on Analytical Chemistry for both the chemist and the materials testing engineer. While differing in nature and scope, it supplements the "Book of Standard Methods" of the American Society for Testing Materials. It is hoped that future editions will still further extend the number of subjects covered.

(Instruments Book Shelf continued on Page 378)

American Standards Year Book 1929. American Standards Association, New York, 1929. Paper, 7¾ x 10½, 88 pages.

Reviewed by M. Berg Rimbach

The Year Book lists about 150 national standards which have been completed and about 175 other national projects now under way. It also lists nearly 550 trade associations, technical societies and other organizations which have been cooperating in the establishment of industrial standards under the Association's procedure and approximately 2200 individuals who have been active in the work of the technical committees engaged on the projects.

Untersuchung Von Spannungs und Schwingungsmessern Fuer Bruecken. *Dr. W. Hart & F. Huelsenkamp.* Verlag der Verkehrswissenschaftlichen Lehrmittelgesellschaft bei der Deutscher Reichsbahn, Berlin, 1928. 58 pages, Price $1.00.

Reviewed by Max Hartenheim

All types of tension and vibration meters which are used at the present time for the determination of the behavior of iron and steel structures under actual service conditions possess certain inaccuracies, for the determination of which no reliable method existed. A contest was arranged to encourage the development and construction of such meters and this report describes and discusses the five tension meters and the five vibration meters submitted for tests. The apparatus were subjected to vigorous tests for accuracy, permanency, resonance, which are communicated with all details. The result, however, was that, although the real purpose of the contest to obtain a useful, reliable instrument, was not achieved, yet, many improvements were obtained and the defects show the way for further improvement.

Die Dauerfestigkeit der Werkstoffe und der Konstruktionselemente. *Otto Graf.* Verlag von Julius Springer, Berlin, 1929. Paper, 7 x 10, 131 pages. Price 14 RM.

Reviewed by E. Fetz

The book is a review of our knowledge of the permanent strength of material when subjected to repeated and long-continued stresses. It brings together in convenient form the available results of tests by the author and other engineers. The materials discussed include: cast iron, cast steel, copper, nickel, aluminum, magnesium and their alloys, as well as stone, reinforced concrete, wood and glass.

Geophysical Prospecting. Papers and discussion presented at meetings held at New York, February 1928, and at Boston, August 1, 1929. Amer. Inst. Min. & Met. Eng., N. Y., 1929. 667 pp. Price, $5.00.

The aim of this collection of papers is "to make available to the mining public sound information concerning the principles underlying the various (geophysical) methods now in active use (for the detection of buried structures), to provide examples of current practice and results, and to afford opportunity for specialists to publish recent achievements and to receive the benefit of criticism and discussion by their colleagues."

The volume contains two introductory chapters emphasizing the value of geophysical methods to the mining engineer, the bridge and dam builder and the searcher for ore. These are followed by 9 papers discussing the electrical methods employed in prospecting, 7 on magnetic methods, 6 on gravity methods and 3 on seismic methods. Nearly all the articles are critical descriptions of the methods outlined. They are abundantly illustrated with plans and sections, and many of them give specific instances of their success in discovering geologic structures. About half are followed by discussions which, in some cases, bring out more clearly than the articles themselves the precise views of their author. The book treats the subjects with which it deals in technical rather than a popular manner. It should serve as an excellent text-book for those who are sufficiently versed in mathematics to read it understandingly. It is well printed and abundantly illustrated.

The Theory of the Gyroscope Compass and Its Deviations. *A. L. Rawlings.* Macmillan & Co., London, 1929. 191 pp. Price, $4.00.

A very full account of the various types of gyroscopic compass, with a discussion of all the principal errors, are given in this book. Chapters I-III deal with the general theory, the mathematics being in a form which can be easily followed by the engineering reader. Chapters IV-VI describe various modern types of gyro-compasses. Chapter VII considers the question of compensating typeweights. Chapters VIII and IX are devoted to the very fundamental "Intercardinal" rolling error, which occurs when rolling takes place on a course inclined to the N.—S. and E.—W. direction, and which caused great difficulty in the earlier days of the gyro-compass. The various ways of overcoming it are discussed and an explanation of the working of the Harrison-Rawlings device of liquid friction in a pipe connecting two mercury boxes is given in this connection. Chapter X treats of "damping-acceleration" error and Chapter XI gives quite a good account of the geometrical errors of reading of the card, due to gimballing. These errors were first recognized and explained by Dr. G. T. Bennett, at the Admiralty Compass Observatory during the War, but little attention is still paid to them and their inclusion forms a noteworthy feature of the book. Finally, Chapter XII gives a short account of a practical test of such a compass.

The Water Current Meter

Paul E. Hoff

STREAM velocities and discharges are determined by current meters. Years past, approximate results of such measurements sufficed. Mechanical devices, based on the assumption that stream velocities bear a definite relation to their forces, were designed and generally accepted. These same devices, only slightly modified, are in service today. Increasing demand for greater economy in the distribution of water, naturally requires greater accuracy in measurement.

Investigations disclosed that the relation between flow velocity and meter action is not the same at all velocities. Friction was held responsible, sensitiveness was thought to be missing. However, an almost frictionless meter failed to bring the expected relief. Studies were then directed upon "the relation of stream flow to meter action," which have given a better understanding of the current meter situation.

The assumption, that stream velocity is proportional to its force, may be acceptable but to make it, unconditionally, the basis for designing a mechanical meter is not justified. It is essential to retain for meter action the natural flow whose velocity is to be determined. To operate a mechanical device by the forces of flowing water and retain the originality of the flow condition is inconceivable.

Observing the movement of stream layers as they meet an obstruction reveals that some layers, by changing their flow direction, find a ready getaway, others are forced against the obstruction endeavoring to find an early chance to escape. The layers, so retarded in their progress, exert their respective pressures, aiming to remove the obstruction. Thus the formerly regularly moving layers upon reaching the obstruction, appear to be in a state of turbulence.

It is characteristic of flowing water that its particles exert their individual forces whenever the occasion arises, they are not bound to adjoining particles except by their fluid cohesion. The flow condition and the distribution of flow forces, in the vicinity of an active current meter, are in an actual turmoil, one resultant of which is the meter rotation.

At low velocities, when the forces of the individual stream lines attack the slowly moving rotor at its many surfaces, irregular in reference to their angular relation to the flow direction, the rotation differs from that at high velocities, when the rapidly moving stream lines press collectively against the meter which, because of its high rotation, has lost the effectiveness of the irregular form of its rotor. (The whole meter appears like a single flow obstruction.) The high velocity rating curve substantiates this view, it proves that the relation between velocity and meter rotation is constant.

Current meters are rated to establish the ratio between meter rotation and the flow velocity. This is done at rating stations where provisions are made to move a rigidly supported meter at various velocities in a definite direction through still water. While this is contrary to field practice, where the meter is held stationary and meets the stream flow, meter

rating in still water is the only method, economically available, to have and maintain a definite relation between the position of the meter axis and the direction of travel or the flow direction.

There has been and still is some disagreement concerning the adopted method of meter rating and a perfect agreement is not likely to be reached. It will be difficult to find a natural flow suitable for the purpose and even artificial channels of flowing water would prove very costly to provide with sufficient water for a large number of flow velocities. Experimentally both of these methods have been tried in Europe where the results were found surprisingly identical.

The water, flowing a certain distance, will cause a certain number of meter rotations regardless of the time consumed in the travel, that is the basis for current meter work. Meters with freely exposed rotors will do that, providing the flow direction in relation to the meter axis will remain constant and the relation between flow forces and instrument inertia does not change.

In reality the rating station seems to be the only place where the flow direction is constant in reference to the position of the meter axis. The relation between flow forces and instrument inertia can be constant only at high velocities when inertia is negligibly small in comparison to the flow force. At lowest velocity no rotation will occur because the inertia is too great to be overcome by the minute flow forces. With increasing velocity, meter rotation begins, the flow forces increasing while the inertia remained virtually unchanged. Continued increasing velocity makes the inertia appear negligible when compared with the prevailing velocity forces, thus the constant relation is established.

There is an uncertainty regarding the value of "rotation at low velocities" as to its "representing the true flow velocity." Where slow moving stream layers meet a partially moving flow obstruction, the layers also their forces are in a state of confusion, it therefore seems rather bold to assume that the resulting meter rotation should represent the actual flow velocity. A careful study of the meter rating curve will rémove the uncertainty regarding reliability of meter action.

The high velocity rating points, when plotted, fall in such a manner that a connecting line of a majority of them is a straight line, its continuation passes through the origin. This means that the high velocity rating curve is identical with the ideal curve (obtained from ratings of an imaginary, perfectly frictionless meter of the same type). Utilizing this ideal curve as a reference line for establishing the high velocity curve (connecting a majority of the high velocity rating points with the origin by means of a straight-edge), it will be seen that all low velocity points fall consistently below the reference line. The point of lowest velocity is farthest from the line, as velocity increases the points come nearer until, at what may be called the critical velocity the points merge with those of the high velocities. It is this merging that determines the efficiency of the meter. The lower the critical velocity, the wider is the range of usefulness of the meter.

It is evident that mechanical current meters can not be faultless measuring instruments but the most efficient and reliable meters are the ones that are least flow obstructing.

Measurement of Air Flow

E. Ower, B.Sc. (Lond.), Hons.I., A.C.G.I.
Bramwell Medallist; Member of the Institution of Heating and Ventilating Engineers; Assistant in the Aerodynamics Department, National Physical Laboratory

CHAPTER III.

THE DESIGN OF PITOT AND STATIC TUBES.

It was shown in the last chapter that the velocity head is, in general, obtained as a difference of two pressure observations—the total head and the static pressure—of which the former can be accurately determined by means of an open-ended tube facing the stream. This method is, in fact, universally adopted for the measurement of total head, the facing tube being known as the Pitot tube after the French scientist Pitot, who appears to have been the first to use it for this purpose. Abundant experimental evidence exists in confirmation of the fact that the pressure indicated by the facing tube is accurately equal to the total head, and that the form of the tube may be varied within wide limits without sensibly affecting the observed pressure. No such latitude is possible in the design of a tube to measure static pressure: for this purpose it is essential to observe the condition already stated, namely, that the flow past the static orifice must be, as far as possible, the same, both in speed and direction, as it was in the free stream undisturbed by the presence of the instrument.

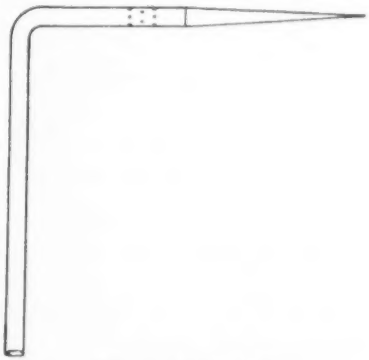

Fig. 3.—Static tube.

On the basis of these requirements the development of static pressure heads has proceeded upon the general lines of the instrument shown in Fig. 3. It will be seen that the head of the tube which is introduced into the air current is bent at right angles to face the stream, its walls being parallel to the

Editor's Note: INSTRUMENTS has secured the American publication rights of "The Measurement of Air Flow" by E. Ower. This treatise will be published serially in INSTRUMENTS, the first installment appeared in the October, 1929 issue. The complete treatise can be obtained from the INSTRUMENTS' Book Shelf.

direction of flow, and terminates in a conical plug of gradual taper merging smoothly into the tube without a gap or change in external diameter. This form of head deflects the air only slightly, and at a short distance back from the tapered portion, where the flow is once more sensibly parallel to the tube, a number of small holes is drilled. The other end of the tube is connected to a manometer, and if the head is suitably proportioned (see below) the true static pressure will be observed. In drilling the holes in the walls of the tube it is essential that no burrs be left on the outside.

The Pitot-Static Tube.—Fig. 4 shows a convenient form

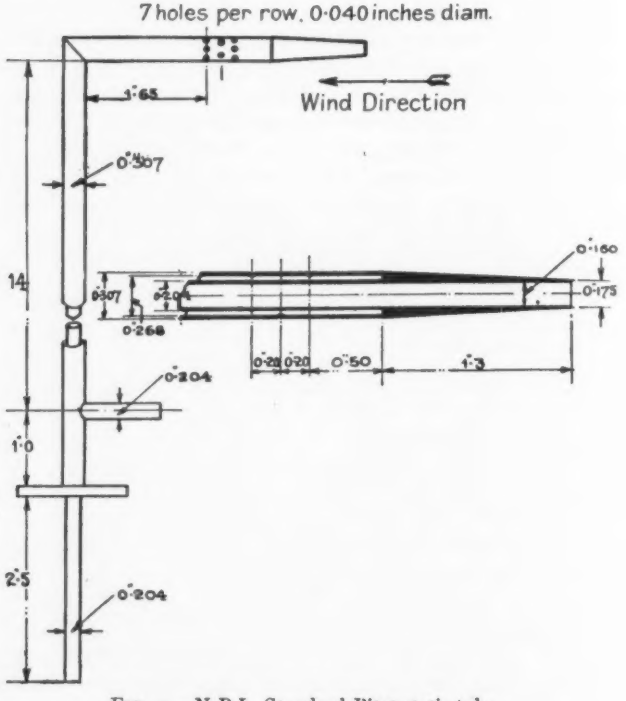

FIG. 4.—N.P.L. Standard Pitot-static tube.

of combined Pitot and static instrument in which the two tubes are arranged concentrically. The apparatus is constructed of brass tubing to the dimensions shown in the diagram, the outer tube, which serves for the determination of static pressure, being tapered and closed at the end, with the static holes arranged on the parallel portion, while the inner tube measures the total head. This instrument was devised and calibrated at the National Physical Laboratory,* and the static side was

* Reports and Memoranda, No. 71, of the Aeronautical Research Committee—December, 1912.

found to indicate the true static pressure to an accuracy of 0·1 per cent., which was within the limits of observational error. In order to effect a measurement of air speed, the two tubes are connected by means of rubber tubing to opposite sides of a differential manometer,† and the resultant reading indicates the speed of the air past the mouth of the tube facing the current. It should be noticed that the static pressure is measured about 2 inches downstream of the region at which the total head is observed. Strictly, of course, the two pressures should be measured at the same point if the speed is to be deduced from the readings. No sensible error is, however, introduced by the more convenient practical arrangement adopted, since the static pressure gradient along an airstream is normally never sufficiently great to give rise to an appreciable difference of static pressure at two points so near together.

In view of the satisfactory performance of this instrument, it has been adopted by the National Physical Laboratory as their fundamental standard against which all other anemometers are calibrated. Copies of this standard are now in general use, and it may be noted that these copies do not require calibration if they conform faithfully to the dimensions of the standard shown in Fig. 4, particularly as regards the taper of the head, and the distances back from the nose of the static holes and the stem (i.e. the portion of the instrument perpendicular to the head). The static pressure reading is sensitive to quite small variations in these dimensions, and if for some reason it is convenient to construct the instrument of tubing of diameter different from that shown in the diagram, it is essential to alter the external dimensions of the head in the ratio of the new to the original diameter, so that the new head is geometrically similar to its prototype.

Although this instrument provides a perfectly definite and trustworthy standard, it is subject to certain defects when considered from the standpoint of the practical engineer. Reference has been made to the need for accurate reproduction of the shape of the head in the manufacture of duplicates, if the calibration is to remain unchanged, and it will be instructive to examine more closely the reason for this necessity. The pressure distribution in the vicinity of the nose of the instrument has never been actually determined, but there can be little doubt that it will be somewhat of the nature of that shown in Fig. 5, in which the ordinates represent the pressures normal to the surface of a model of an airship envelope. It will be seen that near the forward end there is a region of positive pressure (i.e. above atmospheric) which is rapidly succeeded towards the tail by a negative pressure zone extending

† See Chapter IX.

for a considerably greater length. Experience indicates that the pressure distribution round the nose of the static tube is similar to that shown in Fig. 5 with, probably, the forward region of positive pressure relatively much shorter, and that the static holes, as normally situated, lie within the low pres-

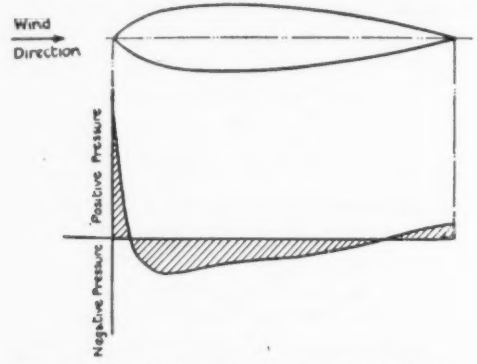

FIG. 5.—Distribution of pressure on airship hull.

sure area, so that, in the absence of other effects, the static pressure recorded will be too low. It is found also, however, that the presence of the stem introduces a region of higher pressure upstream of itself which extends to a distance well beyond the position of the static holes.

There is thus no *a priori* reason why the pressure recorded at the static holes in the standard static head should be the actual static pressure; the fact that it is so would appear to be fortuitous, and to depend upon the somewhat precarious balancing of opposite effects—a positive pressure due to the stem and a suction due to the flow round the nose. This fact assumes importance when, as comparatively often happens in practice, it is convenient to employ a long, straight form of instrument in which the stem is either absent, or considerably further down wind from the nose than in the standard form. In such circumstances the observed static pressure will be in error, even if the head itself is otherwise of standard shape. It would obviously be an advantage to have as a standard a form of head whose readings would remain sensibly constant irrespective of the position of the stem and, within reasonable limits, of the shape of the nose.

The Characteristics of Static Tubes.—In order to establish the characteristics of static tubes and to determine the chief factors influencing their design, the author, in conjunction with Mr. F. C. Johansen, B.Sc., undertook a research on the subject which is described in Reports and Memoranda, No. 981,* of the Aeronautical Research Committee. The investi-

* *The Design of Pitot-Static Tubes* (Ower and Johansen). See also *Colliery Engineering*, October, 1927.

gation was designed to throw light on the best position for the static holes, the effect of variations in the shape of the nose, and the influence of the stem on the static readings. For this purpose a straight brass tube $\frac{5}{8}$ inch in external diameter and about 5 feet long was selected. At one end provision was made for fitting a rubber connecting tube leading to a sensitive manometer; the other end was faced square and tapped internally to take any one of a number of differently shaped heads, which were similarly screwed and were thus interchangeable. Starting from this end, twenty sections were chosen along the tube, and at each section four pressure holes, 0·05 inch in diameter, equally distributed round the circumference, were drilled through the walls of the tube. The spacing of the sections and details of the tube and the heads are shown in Fig. 6.

Four heads in all were tested; of these, three were tapered, one, which had a taper of one in ten, being geometrically similar to the head of the N.P.L. standard instrument (see Fig. 4), and the other two having respectively half and twice this taper. In each case the maximum outside diameter was twice the diameter at the smaller end of the taper, and the head was bored out internally for some distance back from the nose, as shown in Fig. 6, in order to represent the front of the impact tube. The fourth head was hemispherical, the diameter of the aperture representing the impact tube being, as for the other heads, half the diameter of the main tube. A narrow shoulder turned on the base of each head, as shown in the diagram, fitted against the faced head of the main tube, and served to provide a flush joint which was easily rendered leak-tight by the application of a small quantity of vaseline to the screw thread.

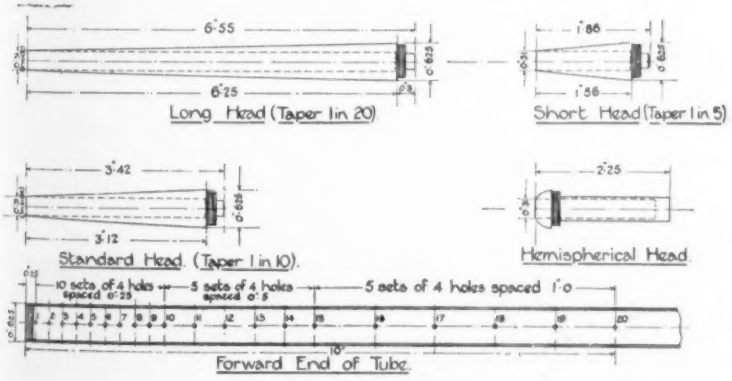

FIG. 6.

Some doubt was at first felt as to the requisite depth of the openings representing the mouth of the impact tube. It

was thought that this depth might conceivably affect the flow round the nose, and thus also the pressures observed at the various static holes. Preliminary experiments with two of the heads, however, in which the depth was varied by means of cylindrical plugs fitting the opening, showed that no measureable effect due to this cause could be detected, even when the forward end of the plug was flush with the mouth of the opening.

For full details of the experiments the reader is referred to the original report mentioned above. Briefly, the investigation consisted in supporting the tube, with one or other of the heads attached, with its length along the axis of a wind tunnel,* i.e. parallel to the wind, and observing the difference between the pressure recorded at the pressure holes at each section in turn, and the true static pressure in the empty tunnel as measured by the N.P.L. standard instrument. Initially, all the pressure holes were stopped up with a mixture containing equal parts of ceresin and vaseline previously melted up together, which formed a conveniently plastic medium for making the holes leak-tight. The surplus was then cleaned off, leaving a flush smooth outer surface to the tube, and the pressure holes at the section at which measurements were to be made were opened, so that the pressure acting on the tube at this section was transmitted to the manometer. When this pressure had been observed the holes were again closed with the filling medium, and the procedure was repeated for the next set of holes, and so on until the pressure at each section had been obtained and compared with the true static pressure at the position occupied by the section. Observations were made at a number of air speeds up to a maximum of 70 feet per second, with the tube fitted in turn with each of the four heads. The data furnished by these experiments, which we may for convenience term series (*a*), served to establish the effect of variations in the shape of the nose, and to indicate the best position of the static holes. For the determination of the effect of the presence of the stem (series (*b*)) measurements were made at one set of holes only, the pressures there being recorded for various positions of a vertical rod representing the stem of the combined Pitot and static instrument and of the same diameter as the main tube, as the rod was moved along the tube towards the holes, starting from a considerable distance downstream. The holes selected for these measurements were situated in the twelfth section from the forward end of the tube, since the re-

* A wind tunnel is a large duct of square or circular cross-section along which a uniform steady current of air is made to move at a known speed, which can be adjusted at will to any value within certain limits. It is a piece of apparatus much used in aerodynamic research. For a full description reference may be made to *Applied Aerodynamics* (Bairstow), or to the reports of the Aeronautical Research Committee.

sults of series (*a*) indicated that for all the heads tested the pressure variation along the tube had become inappreciable at this section.

The results of these experiments supplied comprehensive information relating to the design of static tubes, and they are discussed in some detail below.

Series (*a*).—Fig. 7 shows data obtained with the four heads at an air speed of 70 feet per second. The ordinates represent the differences between the observed pressures at the various sections and the true static pressure at these sections, the differences being expressed as percentages of the quantity $\frac{1}{2}\rho v^2$; the abscissæ denote the distances of the sections from the forward end of the main tube (i.e. from the commencement of the parallel portion downstream of the head) expressed in terms of the external tube diameter. It should be noted that, expressed in this manner, any selected ordinate represents the percentage error on $\frac{1}{2}\rho v^2$ which would be obtained from a total

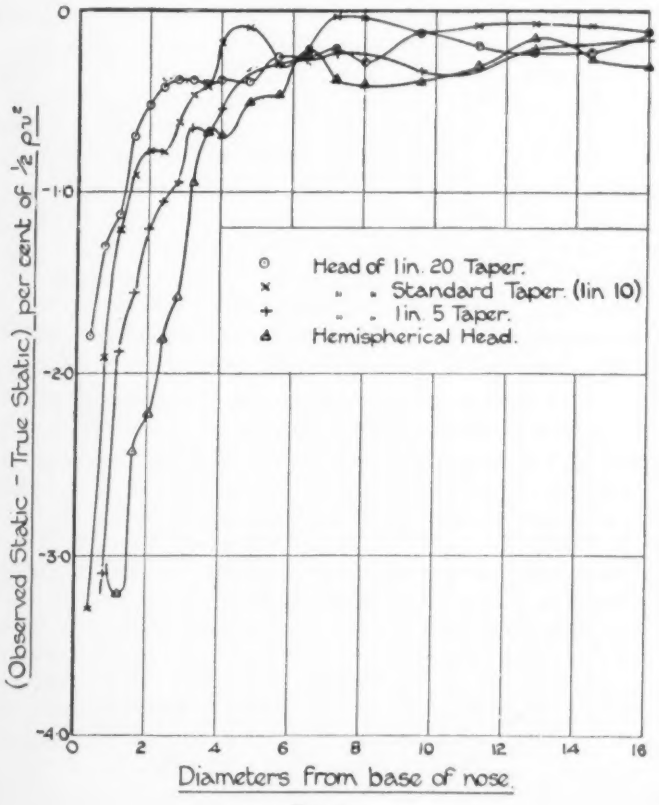

FIG. 7.

head tube used in conjunction with a static tube of the form shown and having its pressure holes in the selected position.

It will be seen from Fig. 7 that in every case a lower pressure was recorded than that observed with the standard instrument, and that the gradient of normal pressure along the tube exhibited the same characteristics for all the heads tested. For the first 3 or 4 tube diameters from the commencement of the parallel portion the pressure variation is rapid, but from about 5 diameters onwards the mean gradient becomes almost zero, and the pressure tends to approach a constant value. A noteworthy feature of these measurements is the fact that the position of the beginning of the parallel portion of the tube appears to be the main factor which determines the longitudinal pressure gradient. Thus, the longest head (taper 1 in 20) extended 10 diameters upstream of the end of the tube to which it was attached, and the shortest—the hemispherical head—only about $\frac{1}{2}$ diameter, a difference of $9\frac{1}{2}$ diameters. Nevertheless, the difference in the positions at which the gradients for these two heads become sensibly horizontal is only about 3 diameters, the region of approximately constant pressure being reached at about 3 diameters with the long head, and with the hemispherical head at about 6 diameters, from the end of the main tube. It should also be observed that the ordinates of the more or less horizontal portion of the gradient are approximately the same for all the four heads, at any rate up to 20 diameters from the end, which represented the limit of the experiments. A mean value for this ordinate would appear to be about $-0{\cdot}25$ per cent. of $\frac{1}{2}\rho v^2$.

The effect of the shape of the head is clearly shown by the results as plotted. Over the region where the pressure gradient is steep, the ordinates at any position along the tube are in the order of bluffness of the four heads, being greatest for the shortest and bluffest head (hemispherical) and least for the longest and most gradual head—that of 1 in 20 taper. After the pressure has become approximately constant along the tube, however, no systematic effect due to the shape of the head can be detected.

It is possible at this stage to consider, in the light of these experiments, where the static holes can best be placed. Reference to Fig. 7 indicates that it is inexpedient to put them at a distance less than 5 diameters from the end of the tube, since, in addition to the steepness of the pressure gradient, which is itself an undesirable feature if steadiness and constancy of readings are to be obtained, the variation with the shape of the head in this region is pronounced. In the existing N.P.L. standard the centre row of static holes is only 2·3 diameters from the commencement of the parallel length of the tube, and

it will be evident that in these circumstances the apparatus, regarded as a precision instrument, might be expected to be unduly susceptible to relatively small changes in the shape of the head. It would appear, however, in view of the steep pressure gradient at this position, that a more effective cause of small differences in calibration from one instrument to another would be small errors in the longitudinal disposition of the static holes. In a head which would permit of more latitude in manufacture without affecting its calibration, the static holes should be about six diameters back from the end of the tube, where the pressure gradient is gradual and the effect of an alteration in shape is, within very wide limits, inappreciable.

Series (*b*).—The effect of the stem was observed for three heads, and the results are reproduced in Fig. 8. In this diagram the abscissæ represent the distances of the stem aft of the static holes (in this case those situated in the twelfth section from the forward end of the tube) expressed in terms of the tube diameter. The ordinate at any abscissa represents the excess pressure produced by the stem in this position over the pressure at the section when the stem is absent, this excess pressure being, as before, expressed as a percentage of $\frac{1}{2}\rho v^2$. It will be seen that the presence of the stem increases the pressure in front of it, the effect being appreciable for a considerable distance upstream ; a further feature which attracts attention is the fact that the shape of the head exerts no perceptible influence on the observed increase of pressure. This increase is very marked at a short distance ahead of the stem ; when the latter is 2 diameters behind the static holes, for example, the pressure is raised by nearly 4 per cent. of $\frac{1}{2}\rho v^2$, and the increase does not fall to 0·5 per cent. until the stem is 15 diameters behind the holes.

In the N.P.L. standard instrument the stem is some $6\frac{1}{2}$ diameters behind the median plane of the static holes. Reference to Fig. 8 shows that, at this distance, the presence of the stem augments the static pressure by about 1·4 per cent. If an instrument is used, therefore, which conforms in all respects to the N.P.L. standard, except that the stem is absent, it is to be expected that an error of 1·4 per cent. on $\frac{1}{2}\rho v^2$, i.e. 0·7 per cent. on v, will be incurred, which is unduly large for accurate work.

Definite indications are furnished by the results of experiments (*a*) and (*b*) of the features to be observed in the proportioning of static heads. From series (*a*) it is apparent that the static holes should be not less than 6 diameters back along the parallel portion of the tube, and from experiments (*b*) that the stem should be at least 15 diameters behind the static

holes.* These two requirements would combine to produce a head which would be considerably longer than that of the existing standard instrument, but this unavoidable increase in length can be appreciably reduced by substituting a hemispherical nose for the present taper. This course would appear to be permissible, since the results of experiments (*a*) showed that the effect of the shape of the nose was not felt beyond about 6 diameters downstream from the end of the parallel portion. By the use of such a hemispherical nose a saving

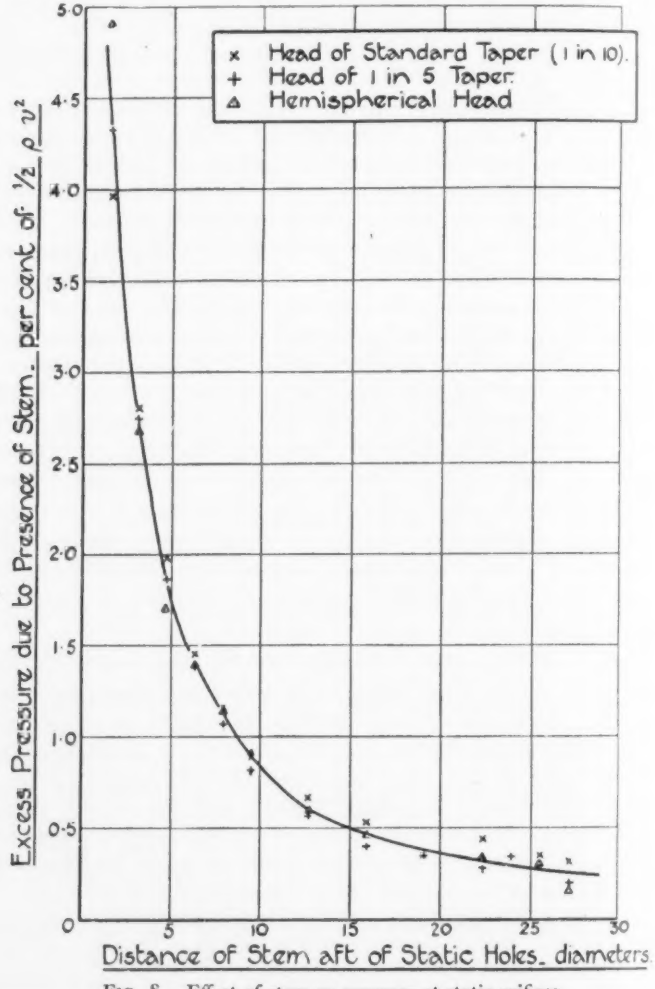

FIG. 8.—Effect of stem on pressure at static orifices.

* Observance of the latter condition ensures that the error in static pressure incurred by the use of an instrument in which the stem is entirely absent will be limited to 0·5 per cent. of $\frac{1}{2}\rho v^2$.

in length of $4\frac{1}{2}$ diameters will be effected, and there will be the additional advantage that the distance between the static holes and the mouth of the total head tube will not be so great that the effect of a static pressure gradient along the direction of the airstream will be felt. In fact, in the proposed arrangement, with tubes of the same diameter as those at present used in the N.P.L. standard, this distance will be slightly less than the corresponding distance on the standard.

This reasoning led to the construction of the modified Pitot-static tube shown in Fig. 9. The tubes used were of the same diameter as those of the original standard, the outer one being 0·307 inch external diameter, and the mouth of the total head tube 0·157 inch inside diameter. The single row of 7 static holes, 0·038 inch in diameter, was situated 6 external diameters back from the base of the hemispherical nose, and the axis of the stem was 15 diameters behind the holes, so that the total length of the head was 6·58 inches.

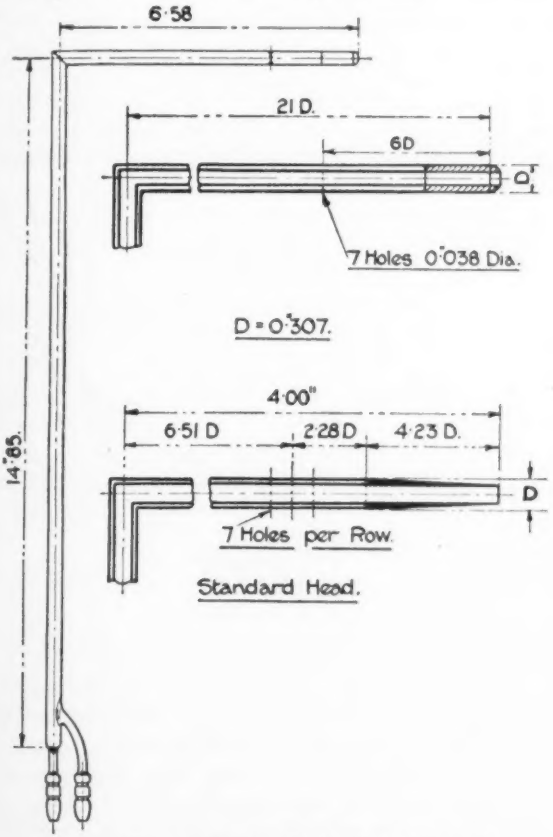

FIG. 9.—Pitot-static tube with hemispherical head.

The static side of this instrument was calibrated in the wind tunnel against the N.P.L. standard tube, at wind speeds ranging from 20 to 70 feet per second, and it was found that the modified tube indicated a slightly lower value for the static pressure than the standard, the mean difference over the range of wind speeds tested amounting to 0·6 per cent. of $\frac{1}{2}\rho v^2$ On the assumption that the total head tube reads accurately (and one or two tests indicated that this was the case), it is to be inferred, therefore, that the readings of the combined instrument will be 0·6 per cent of $\frac{1}{2}\rho v^2$ higher than those given by the existing standard.

It may be observed that by putting the stem further forward the error in the static pressure recorded by this instrument can be entirely eliminated. For this purpose the stem must be advanced so that it produces, at the region occupied by the static holes, a pressure which is 0·6 per cent. of $\frac{1}{2}\rho v^2$ greater than that in the instrument as actually designed. Thus, instead of giving a pressure of 0·5 per cent. of $\frac{1}{2}\rho v^2$ at the holes, the stem must be situated so that it gives a pressure of 1·1 per cent. of $\frac{1}{2}\rho v^2$, and Fig. 8 shows that this occurs when the stem is about 8 diameters behind the holes. An instrument having a head shaped as in Fig. 9, with the stem 8 diameters behind the static holes, may be relied upon to measure wind speed to an accuracy of about $\pm$ 0·1 per cent.

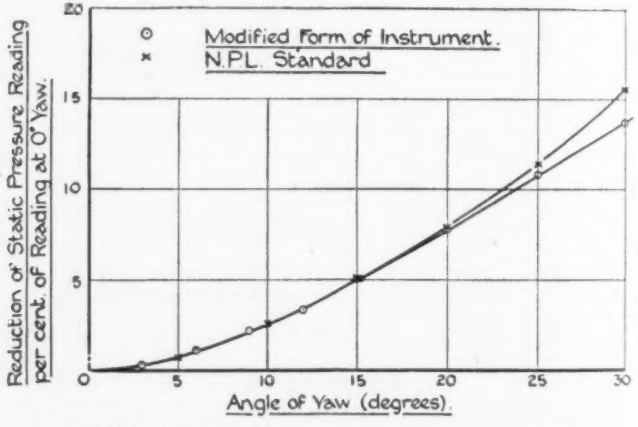

FIG. 10.—Effect of yaw on static pressure reading.

Tests were also conducted with the modified instrument to determine the effect of inclinations of the head to the wind direction. For this purpose the instrument was mounted with the stem vertical in such a manner that the head could be rotated or "yawed" through known angles in a horizontal plane. The results are plotted in Figs. 10 and 11, which relate

respectively to the effect of yaw on the static pressure readings, and on the readings of the combined instrument, i.e. the square of the velocity head. For static pressure the results are given as percentages of the reading at zero angle of yaw (head parallel to wind), and it will be seen that the effect of yaw was to reduce the pressure at the holes. As regards the readings of the combined instrument, the results are expressed in the form of the ratio $\frac{P_\theta}{P_0}$, where P_θ and P_0 are the readings at $\theta°$ and 0° yaw respectively. The results show that this ratio increased up to 16° yaw, where it had a maximum value of 1·045, and then decreased, passing through unity at about 25·5°. It appears therefore that, up to this angle, the maximum error that will arise in the measurement of velocity with this instrument will be + 4·5 per cent. of v^2, i.e. 2·3 per cent. of v; up to 30° yaw the error in v may be ± 2·3 per cent., and the instrument may be as much as 11° out of alignment before the error exceeds 1 per cent. For comparison, the results of similar tests on the

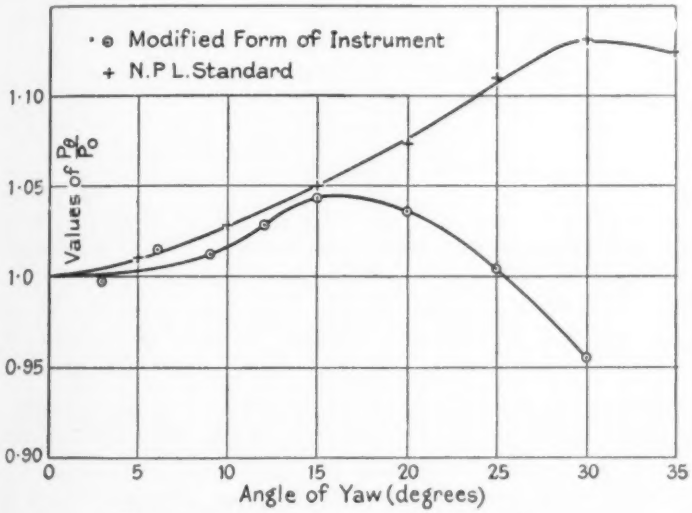

FIG. 11.—Effect of yaw on velocity head reading.

N.P.L. standard instrument are included in Figs. 10 and 11, and indicate the definite superiority of the modified instrument as regards sensitivity to errors of alignment to the true wind direction. For example, between 0° and 30° yaw the possible error in the measurement of air speed with the standard is about 5½ per cent. as compared with the corresponding maximum of 2·3 per cent. with the modified type.

In view of the satisfactory performance of this instrument

the author is definitely of the opinion that it may with advantage be used, in preference to the existing pattern, for general practical work. In the first place, as a result of its low sensitivity to changes of shape, its construction calls for no great accuracy of workmanship; small errors in the longitudinal disposition of the static holes, and quite large variations in the form of the nose, will not affect the calibration to any perceptible degree. It follows that all instruments of this type, made with ordinary workshop precision to the dimensions shown in Fig. 9, may be confidently accepted, without tests against a standard, as having the same calibration as that obtained in these experiments. That is to say, all such instruments will indicate a value of the velocity which is 0·3 per cent. too high, and if a head of this type is used in which the stem is entirely absent, an additional error of only 0·25 per cent. on velocity will be incurred. Both these errors are negligibly

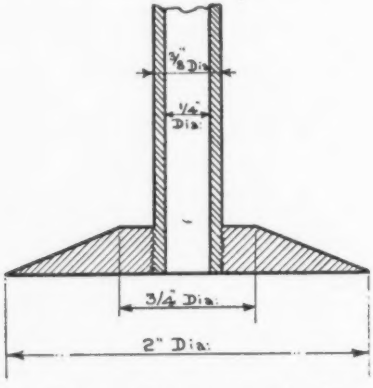

FIG. 12.—Disc type static head

small for ordinary engineering practice, but in any case they are quite definite and due allowance may be made for them if desired. Further, this instrument is distinctly less sensitive than the existing standard pattern to errors of alignment with the wind direction, a feature of considerable importance in many practical cases where the direction of the current is not known to about 10° or so. Finally, the hemispherical head is more easily made and is much more robust than the present tapered type. The latter terminates in a thin feather edge which is very liable to become damaged, with the consequent possibility of a change in calibration.

Disc Static Heads.—In a dust-laden airstream the small holes in a static head of the tubular type are liable to become blocked, and for measurements under such conditions heads

of the type shown in Fig. 12 are sometimes used. Experiments by Heenan and Gilbert have shown * that these heads give all the accuracy ordinarily required in the measurement of static pressure. It is important that the face of the disc should be smooth and that the tube connecting the orifice to the mano-

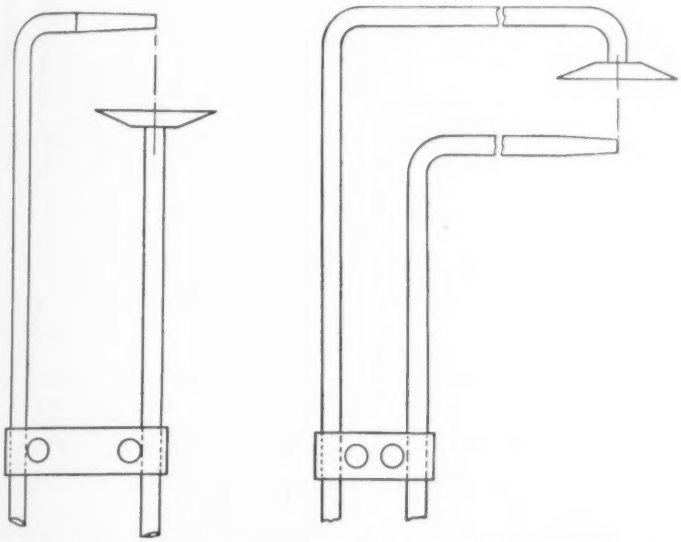

FIG. 13.—Combinations of disc static heads with total head tubes.

meter should end flush with the disc surface. Such heads are either used in conjunction with the usual form of total head tube, as illustrated in Fig. 13, where two possible arrangements are shown, or, alternatively, the measurements of static pressure and total head may be made separately as explained in Chapter V.

* *Proc. Inst. Civil Engineers*, vol. cxxiii:, 1896, "The Design and Testing of Centrifugal Fans."

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CHAPTER I (*Cont'd.*)

The Historical Development of the Measuring Science and the Systems of Length and Weight

by
DR. FRITZ PLATO
Director a. d. Reichsanstalt fuer Mass und Gewicht

3. THE METRIC SYSTEM AND THE INTERNATIONAL METER AGREEMENT

The metric system had its origin in France. Until the end of the eighteenth century, an incredible confusion existed there. It was no better in other countries: i.e., in Germany alone 132 different ells were in use. In the many small states, though, this disagreeable state of affairs was not felt as much as in the uniformly regulated and governed France. The desire of the people for the same weights and measures in the whole country was, therefore, very pronounced quite early, and in the year 1789 a number of important French towns appealed to the Constituent Assembly that this multiplicity be abolished by statute. The assembly recognized the justification of the desire, and resolved on the motion of Talleyrand-Perigord on May 8th, 1790 to ask the king to have the government of Great Britain name a commission of members of the Royal Society which should in conjunction with a commission of members of the French Academy, determine the length of the seconds-pendulum at any latitude, and derive from this an invariable embodiment for all weights and measures. After the king had approved of this resolution on August 22nd, Borda, Condorce, Lagrange, Leplace, and Monge were elected members of the commission of the Academy. England did not respond to the invitation.

The French commission was not satisfied to simply accept the proposal of Talleyrand-Perigord but also considered other suggestions. There was no lack of preliminary studies because long before commerce and industry, science had already recognized the importance of a standard unit of universal vadility. The leading viewpoint for the study was that the new unit should be taken from nature but at the same time chosen in such manner that, in case of eventual loss, the original standard could be reproduced at any time. By this decision, the above mentioned natural units based on the human body were excluded from the beginning, for how could the widely used "foot of Charlemagne" be reproduced with even approximate accuracy? Very soon also it was found that no reproducible quantity could be derived from animated nature, and that the non-animated nature offered such a meaure only in the earth itself; that even the latter is not invariable was recognized only in later times. Physical quantities were not considered.

The suggestions to use the earth as fundamental unit were very numerous, but only two achieved general importance. Christian Huyghens used gravity, when for the first time in 1664 and afterwards in his Horologium oscillatorium published in 1673, he recommended the third part of the length of the simple seconds-pendulum as pes horarius. Gabriel Mouton, an astronomer of Lyons, started from the circumference of the earth and in 1670 suggested the selection of the one arc-minute of the earth's meridian as unit of length and to subdivide it according to the decade system. Both propositions were subject to many changes. The National Assembly agreed upon the former, but the committee supported the latter for national and tactical reasons. They gave preference to the Frenchman Mouton and also eliminated the co-operation of Great Britain, "in order to make it known later to which people the idea and the determination of a natural fundamental unit is due." Objection was raised to the pendulum, which under latitude of 45° at sea level and at the temperature of melting ice in a vacuum beats one second (the scientists had agreed on this absolutely determined pendulum), that the latitude of 45° passing through France might be prejudicial to the latter acceptance of the pendulum-unit. The proposal of Mouton was further changed in so far as, instead of an arc-minute, the ten-millionth part of a quarter of the earth meridian was taken. The unit of mass was to be obtained by weighing in a vacuum that amount of pure water at the temperature of melting ice, which is contained in a cube the edges of which have a certain fractional part of the unit of length. That temperature was chosen for the reason that, one would therefore be independent of the different temperature scales. Later, these resolutions were not entirely adhered to, they were changed in that for the derivation of the unit of mass not water at the temperature of melting ice but in the state of its greatest density was used because this could be determined more easily. Further, it was determined that the quantity representing the unit of length should have its true length at the temperature of melting ice.

To obtain the new unit of length the length of a meridian had first to be measured. (Fig. 1.) If the earth were a sphere it would have been sufficient to measure an arc of any length and to determine the corresponding angle. Our planet has a very complicated shape; but, it can be considered, with very great approximation, as a flattened rotation-ellipsoid so that the meridian is determined by two diameters. Accordingly, two arcs had to be measured on the same or on different meridians as to their angles and lengths. From this, two equations were obtained, from which the two diameters, and also the length of a meridian, at the same time also the flattening of the earth could be calculated.

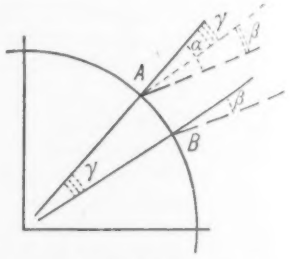


Fig. 1. Measurement of circumference of the earth.

Arc AG is measured by a measurement of length; the two angles α and β are found by astronomical measurement of angles at A and B (measurement of zenital distance of a fixed star). Their difference equals the angular distance α of the two stations the length value of which is known. This is sufficient to calculate the circumference of the earth.

Two such measurements had been made half a century before in order to solve the question as to the true shape of the earth, the one by Bouguer

and Lacondamine in Peru, the other simultaneously by Clairaut and Maupertuis in Lappland. Two steel units having a length of one toise were used for the measurements which later were designated as the toise of Peru and the toise of the North. The latter was badly damaged in a shipwreck while the former arrived safely in France. The committee therefore proposed to use only the measurements in Peru for the derivation of the new unit of length and to supplement it by a further measurement between Dunkirk and Barcelona, i.e., on an arc lying largely in France.

The report of the committee was made on March 19, 1791 and sanctioned by the National Assembly on March 26, 1791. As early as March 30 the royal approval was given, whereby the Academy of Sciences was instructed to name scientists for carrying out this work. Méchain and Delambre took upon themselves the more important part of the task, the geodetic measurements, and carried them out under extreme difficulties, often threatened by death in the confusion of the revolution, with obstinate perseverance and unshakable courage. The length of the pendulum was determined by Borda and Cassini.

The activity of the scientists, who were safe-guarded by a special royal decree, was ended unexpectedly after two years when, on August 8, 1793, the Academy of Sciences was dissolved because parasites were not to be tolerated in the State. The committee for the determination of measuring standards, however, was retained but Borda, Brisson, Coulomb, Delambre, Laplace and Lavoisier were removed from it because their republican sentiments appeared questionable. The dictators of the Republic were finally convinced of the folly of their procedure, and by the decree of November 9, 1795 it was decreed that a new committee of scientists was to be appointed by the committee of public education (comité d'instruction publique) to complete the work already started. This important committee, which finally finished this great task, consisted of: Berthollet, Borda, Brisson, Coulomb, Delambre, Hauy, Lagrange, Laplace, Méchain, Monge, Prony, Vandermonde, to which later were added Darcet, Legendre and Lefèvre-Gineau. For reasons of expediency, a number of scientists of foreign countries were appointed: Ännä and van Swinden for the Batavian Republic, Balbo for Sardinia (he was later replaced by Vassalli Eandi), Bugge for Denmark, Cisyar and Pédracês for Spain, Fabbroni for Tuscany, Franchini for the Roman Republic, Mascheroni for the Cis-alpine Republic, Multedo for the Ligurian and Tralles for the Swiss Republic. An excellent array of scientists among which Tralles and van Swinden stood out.

The geodetical measurements were based on the toise of Peru. In order to preserve it from a fate similar to that of the toise of the North, four definite measuring rods each of a length of about two toises were made of platinum by Lenoir, who also had to supply the repetition circles. To one end of the platinum rod was rigidly fastened a brass rod, which served as metal-thermometer. One of the rods, the so-called modulus, was compared, with all possible accuracy, with the toise of Peru and used as standard for the determination of the other rods. All measuring data were first expressed in parts of the modulus; afterwards the conversion were made into units of the toise of Peru. According to van Swinden, half the modulus at 12.5° C. had the same length as the toise of Peru at 13° R.

Due to the unfavorable conditions of the times, it took seven years until Méchain and Delambre finished their task. Upon conclusion of the observations, the checking of the astronomical and geodetical work was confided to Tralles, van Swinden, Laplace and Legendre. The calculation were made by Tralles, van Swinden, Legendre and Delambre, but each of them had to work independent of the others using his own formulas. The special committee for the quadrant of the meridian was composed, in addition to the four calculators and Laplace, of Ciscar and Méchain. The report was prepared by van Swinden and he published it on April 23, 1799. Two weeks later, May 7, 1799, the committee for checking the measuring rods and for determining their relations to the toise of Peru, the toise of the North, and the toise of Mairon, and composed of Coulomb, Mascheroni, Méchain, Multedo and Vassalli, also made its report.

The comparison of the meridian-arc Dunkirk-Barcelona with the one measured in Peru gave as flattening of the earth 1/334, from which the length of a quadrant of the meridian is obtained as 5,130,740 toises and the length of a meter as 443.295836 Parisian lines. This value is, doubtless, too small. For its derivation only the observations of Bouguer in Peru were used. When Delambre also used the measurements of Lacondamine, he found the flattening of the earth as 1/309. More recent measurements of the degree make it probable that the value can differ but little from 1/300. The standard length of the metric system was, therefore, from the beginning, not according to its conception equal to the 10,000,000th part of a quarter of the meridian but equal to the length of that rod intended to represent this unit. The meter is, therefore, not a natural unit in the strict sense of the word but a conventional unit like all other socalled natural standards as soon as they are represented by a replica. At any rate the representation—the Archives Meter—does not differ from the intended size of the meter by more than about 1/11,000 of this value.

Lefèvre-Gineau had taken upon himself the work of deriving the unit of mass. It had been decided that, that amount of pure water at its greatest density, i.e., at 4° C., which would fill a cube of 0.1 meter length of side, should be considered as the unit of mass. This conception made it necessary to represent the new unit of the kilogram by a weight, as it was not possible to produce the required quantity of water of prescribed quality at any time and any place. Therefore, the kilogram was from the beginning a conventional unit. The weight and the quantity of water should balance each other in vacuum.

Two ways were open to the investigator to carry out his task. He could weigh a vessel of known dimensions empty and filled with water—the difference was then the mass of the water. Or, he could weigh a body first, in vacuum and then in water, he would in this way obtain the mass of the amount of water replaced by the body. Lefevre-Gineau chose the second method. He used a closed brass cylinder the height of which was the same as its diameter, about 0.2435 m. The volume of the cylinder had to be measured directly. In order to obtain as great an accuracy as possible the investigator measured the diameter of the cylinder at 48 places and the height at 37. The diameter was measured on eight sections

equally spaced in height, and at six points on each section equally distributed around the circumference. The heights were distributed uniformly over the whole surface and at equal distances from the center axis. The average for the height was 0.2437672 meters and for the diameter 0.2428368 meters; the volume of the cylinder is, therefore, 0.112900054 cubic meters. This value is for a temperature of 17.6° C. Since a metallic body of 11 cubic decimeters would have been too heavy to be weighed with sufficient accuracy. Lefevre-Gineau used a hollow body the inside of which he connected with the outer air by a narrow tube in order to be more independent of the conditions of the latter. The tube protruded, above the surface of the water, during measurements in water. During these measurements, the water had an average temperature of 0.3° C. In order to be able to convert the observations to water of greatest density Lefevre-Gineau investigated the expansion of water and the change of density with temperature. The weighing was carried out with a set of brass weights balanced among themselves. At first, therefore, the new mass unit was obtained in relation to this set but it was then immediately embodied in a weight of platinum, the kilogram of the Archives.

The committee entrusted with the checking of these tests consisted of Coulomb, Mascheroni, van Swinden, Tralles and Vassalli. The first report was made by Tralles, van Swinden combined the two reports on meter and kilogram to one joint report which was given to the Institut National in May, 1798. On June 22, 1798, the committee submitted to the State Archives in Paris a platinum rod which was to represent, at the temperature of melting ice, the meter, and a platinum cylinder which was to represent, according to the definition given above, the kilogram. Both original standards were made by Fortin in Paris, and are designated as Archives-meter and Archives kilogram. The meter rod was recognized, by the law of December 16, 1799, as "métre vrai et définitif," and since then forms the basis of the metric system.

In its original conception, the metric system knows only one principal unit, the unit of length. The unit of area is a square the sides of which equal the unit of the length, the square meter. Consequently, the unit of space will have to be the cube whose edges are equal to the unit of length, the cubic meter. The unit of volume, however, is defined as the space occupied by a kilogram of pure water at its greatest density at the pressure of one atmosphere. Both quantities, the cubic decimeter and the liter, would be absolutely identical if the kilogram corresponded exactly to its definition. In fact, this is not the case, but it proves the admirable thoroughness of the work of Lefèvre-Gineau that the difference is not more than about 1/30,000. According to the measurements of Macé de Lepinay, René Benoît and Henri Buisson on the one hand and Chappuis on the other, made on five quartz cubes, the value of the liter is: 1 liter = 1.000027 cubic decimeters. For all practical and also most scientific requirements, liter and cubic decimeter can be considered identical, and only for the most exacting chemical and physical measurements will it be necessary to take the difference into consideration.

As regards the nomenclature of the metric system, there was unanimity at first only in that the unit of length should be designated as

meter (mètre). Otherwise, all the old French designations were retained, as palme for 0.1 meter, doigt for 0.01 meter, and trait for 0.001 meter, perche for 10 meters, stade for 100 meters, mille for 1000 and lieue for 10,000 meters; further livre, also grave, for the unit of mass, ounce for the tenth part, etc. The designation, generally accepted at present, in which the Greek words for 10, 100, 1000 (deca, hecto, kilo) are prefixed to the principal unit for the decimal multiples, and the corresponding Latin words (deci, centi, milli) for the decimal subdivisions, is said to have been originated by van Swinden, however, it was already mentioned in the law of April 7, 1795.

This law marks the first attempt to introduce the metric system in France. In their desire to accelerate as much as possible the straightening-out of the question of weights and measures the leaders of the Republic thought it desirable not to wait for the conclusion of the work of the committee; they therefore derived a preliminary value for the meter from previous measurements. This preliminary legal meter (mètre provisoire et legal) whose length was calculated to 443.443 Parisian lines was to form the new unit of length until the final results were established. The application, however, was not compulsory, the law was satisfied to invite the citizens to give proof of their inclination towards unity of the republic by their use of the new units in their calculations and commercial transactions. As the expected success did not materialize and also did not come after the acceptance of the final meter, the foreign designations were at first given up and again replaced by the previously used French expressions. Later even the decimal division was dropped, and finally nothing more was left of the metric system than that the old units were approximated by metric values, i.e., the ell by 60 cm, the pound by 500 gms, etc. Only on January 1, 1840 was the law of July 4, 1837 on the metric system introduced and completely carried out.

In the year 1799 its founders had a commemorative medal made with the proud inscription "A tous les temps, à tous les peuples." At the beginning, their hope expressed therein was not fulfilled as the original failure in their home country did not serve as recommendation for the new units. A turning point was reached, when the North-German Alliance and then the German Empire, founded in the meantime, legalized the metric system by the ordinance of August 17, 1868, to become valid beginning with January 1, 1872.

A few states in Germany had started at the beginning of the 19th century to create order in the question of weights and measures, Württemberg in 1806, Bavaria 1809, Baden 1810, Prussia 1816, but only in connection with the existing units of the respective country without taking the neighboring states into consideration. A step toward unification was made in 1833 with the foundation of the German Customs-Union which in 1837 prescribed a common customs-pound of 500 gms. and a customs-hundredthweight of 100 pounds for paying the customs duties. A few years later all German states with the exception of Austria and Bavaria introduced this pound also in public traffic. Unfortunately, the subdivisions of the pound were again differently fixed in almost every country. The endeavors for unification were, however, not silenced, and in the year 1860 the National Assembly in Franfort-am-Main designated

a committee of authorities to work out suggestions for unified weights and measures. In a thorough report the committee resolved, for political reasons, to chose a foreign system of weights and measures, rather than one in use in Germany. The metric system was chosen due to its many merits. Prussia stood aside at that time; it abandoned its resistance in 1865. The second committee elected, completely accepted the ideas of its predecessor and at once proposed drafting an ordinance of weights and measures. The political events of the year 1866 at first prevented a discussion but on May 13, 1868 the Convention of the North-German Federation accepted the proposal which became a law with the formation of the German Empire.

The original reticence of Prussia had its good reasons and was based on the fact that Prussia possessed standards which were absolutely clear and determined with all possible care, and also compared most carefully with the toise of Peru. The original units of the metric system were, not without objection, especially the embodiment of the meter was not well chosen. The very material used, an impure platinum-sponge, proved to be unsuitable because it could not be properly made at that time, and because it was too soft. Further, the section was too weak especially was the thickness too small, and finally, the selection of a definite unit as a fundamental unit must be considered a failure with the state of the measuring science prevailing at that time, as it did not permit an accurate conversion within a few fractions of a millimeter to the linear units principally important for practical use. To this must be added that the Archives meter had not been handled very carefully; the end-faces determining its length showed distinct impressions due to the contact pieces of the comparator used. As long as the metric system did not go beyond the French borders, this was not a drawback but they became the more obvious the larger became the circle of countries which used the new units because the fundamental standards compared at different times with the Archives meter did not agree among themselves due to the continuous deterioration of the latter. The uncertainties due to this, induced the Director at that time of the Royal Prussian Geodetical Institute, Lieutenant-general Dr. Bayer, to ask the Prussian Academy of Sciences to work toward the appointment of a European Commission which should construct common original standards, distribute their reproductions, and compare them at definite intervals. Scientists of other countries followed the lead of Bayer, then came the scientific institutes, and finally also the governments. France declined at first, but as also at the convention of the European (later International) Measurement of the Degree in 1867, especially at the instigation of the Swiss representative, the Director of the Neuenberg Observatory, Dr. Hirsch, a resolution was accepted in accordance with the suggestion of Bayer, the French Government at last invited the foreign governments to a meeting, and on August 8, 1870 the International Meter Committee assembled in Paris for the first time.

In these discussions and also in the later ones it became quite clear that the French scientists, with few exceptions, were not at all willing to give up the least title of the predominant position which France possessed in the metric system. It was agreeable to have replicas made of

the Archives meter and the Archives kilogram, and to grant a certain influence to foreign countries for the reproduction of the standards, but no further concessions were to be made. England sided with France because she apprehended less danger for her own system from a metric system under French supervision alone. Also, the Dutch representative agreed with France for scientific reasons. Only when the other side under German leadership—the German representative was Dr. Foerster, Director of the Berlin Astronomical Observatory and of the later Imperial Standards Commission—insisted firmly on their will and threatened to found the necessary institute in Bern without France's co-operation, were concessions made and so the International Meter Agreement was finally concluded on May 20, 1875. The agreement stipulated that "an International Bureau of Measures and Weights is to be installed in Paris which is to stand under exclusive management and supervision of an international committee for weights and measures which is placed under the authority of a general conference composed of the delegates of all governments participating in the agreement." The duties of this bureau are: to make all comparisons and certificates of the new prototypes of the meter and kilogram, the safe-keeping of the international prototypes, the periodically recurring comparisons of the national prototypes with the international prototypes and with the so-called Témoins which serve to check the international prototypes and also the periodical checking of the standard thermometers used in these comparisons.

The International Bureau, after the necessary buildings (pavillion de Breteuil in the Park of St. Cloud at Sèvres) had been finished in 1878, at once began its work, and in 1889 its most important task was finished, namely the production and comparison of new international and national prototypes. On September 24, 1889, the International Meter Conference assembled in Paris and stipulated finally that in the future in place of the Archives meter and the Archives kilogram the international prototypes alone should form the only basis for the metric system. These prototypes were selected from 30 simultaneously made measuring rods and weights. The other measuring rods and weights were distributed by lot among the co-operating countries.

According to a resolution of the same conference, the meter is now defined as the distance between the end-lines of a measuring rod (the international prototype) at the temperature of melting ice under a pressure of one atmosphere and deposited in the pavillion of Breteuil. The rod is made of a very pure alloy of 90% platinum and 10% iridium, a combination which seems to offer especial reliability due to its other physical and chemical properties in addition to its strength. The rod has a length of 102 cm. The section is X-shaped and enclosed in a square of 20 mm side length. The upper surface of the middle rib on which the lines are drawn coincides with the neutral plane. The metal has a thickness of about 3 mm. By making the lower legs slightly thinner the neutral plane has been placed in the center of the height of the section. Near the two ends ellipse-shaped faces are smoothly and highly polished on which the limiting lines are drawn. The division on each end consists of three lines 6 to 8 μ (1μ — micron — equals 0.001 mm) wide and separated 0.5

Fig. 2. Section through the prototype meter, full size.

mm from each other, of which the center lines are to serve as principal lines while the others can be considered as auxiliary lines. The position of the center axis is determined by two heavier longitudinal lines drawn on both surfaces 0.2 mm apart.

In order to preserve, at an eventual destruction or injury to the international prototype, the unit of length the 30 national prototypes have been compared among one another in 11 over-lapping groups, namely 5 groups of 6 rods each, and 6 groups of 5 rods each; besides, each of them was compared with the preliminary original standard (called J2) of the International Bureau, and also with the new international prototype M. Finally, these two rods J2 and M were compared with each other. Each complete comparison consists of four special comparisons in the four positions which the rods can have with respect to the microscopes and to the observers.

When measuring the rods must be placed on a horizontal support. The international prototype is to be used without correction in length. The distance of its end-lines is considered to be the exact representation of the meter, and a relation to the Archives-meter is not given. The old French prototypes only have historical value. In commemoration of the founders of the metric system and to prevent inconveniences which could have occurred due to a noticeable difference between the units previously used and the new ones was expressly stipulated that the quantities embodied in the new prototypes should agree exactly with the old French prototypes. In fact, they agree so well that even for the most delicate measurements of science and industry no difference in the length of the Archives meter and the international meter prototype is noticeable. But if this unnecessary requirement is expected each of the national prototypes or each of the 30 rods made simultaneously and remaining in the International Bureau can replace the international prototype without difficulty.

At the 1889 General Conference on Weights and Measures the relation of the meter to the dimensions of the earth had already been abandoned but the connection between unit of length and unit of mass was still retained. At the conference in 1901 this relation was also discarded, and the following definitions were accepted:

1. The kilogram is the unit of mass, it is equal to the mass of the international kilogram prototype.

2. The expression "weight" means a quantity of like kind as a force; the weight of a body is the product of the mass of the body and the acceleration due to gravity; specially, the normal weight of a body is the product of the mass of the body and the normal acceleration due to gravity.

3. The value normally accepted in international use of measures and weights for the gravity is 980.6 cm/sec^2.

Forty-two weight prototypes were made of the same material as the length prototypes. The kilogram has the shape of a straight cylinder 39 mm high and 39 mm in diameter with rounded edges.

In order that a substitute can be obtained immediately in the eventual destruction of, or injury to, the international kilogram prototype the 42 units were compared among each other in 6 groups of 7 units each and in 7 groups of 6 units each, and finally also each kilogram was compared with the new original weight of the kilogram K. The latter compared

in the year 1880 with the Archives-kilogram was found to be equal to it within the limits of errors of observation. In each group the comparisons were carried out in all possible combinations. Each complete weighing consisted of 4 weighings between which the load of the balance was changed in part by the addition of auxiliary weights, partly by exchanging the pans of rock-crystal on which the weights rested during the weighing.

In keeping with the international agreements the square meter forms the unit of area measurement and the cubic meter the unit of volume. With regard to the latter the General Conference on Measures and Weights of October 16, 1901 stipulated the following:

1. The unit of volume for measurements of great accuracy is the space occupied by a mass of 1 kilogram of pure water at its greatest density and under the normal pressure of one atmosphere. The unit of volume is called liter.

2. For measurements of volume not requiring a high degree of accuracy the cubic decimeter can be taken as equal to the liter; and, in these measurements the data based on the cube of the unit length can be replaced by such which are referred to the liter as explained above.

In the preliminary discussions on the International Meter Agreement 14 European and 8 American countries were represented, at its conclusion 13 European and 5 American countries took part, namely: Argentine, Austria, Belgium, Brazil, Denmark, France, Germany, Hungary, Italy, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, United States of America, Venezuela. Later were added: Servia 1879, Roumania 1882, Great Britain 1884, Japan 1885, Mexico 1890, Canada, Chile, Uruguay, Bulgaria 1907, Siam 1912. Brazil and Turkey again dropped out later. In the meantime, other names have been added to the list. The International Meter Agreement is one of the few treaties which have come through the world war practically unimpaired.

For the above reasons the metric system was for a long time naturally confined to France and its immediate neighbors. The introduction of the new weights and measures in Germany promoted its acceptance in other countries. The International Meter Treaty contributed very materially to its spread. At present the metric system is used in all European countries except Great Britain and Russia. It is at present being introduced in the latter country. Exceptional positions are held by Greece and Turkey, for while the metric system was introduced in the former in 1874 and in the latter in 1836, it has not yet been able to replace the old units. In America, the United States refrains from using it, on the other hand the metric units are used in Argentina, Brazil, Colombia, Costa Rica, Mexico, Peru, Porto Rico, United States of Central America and finally Canada. In Asia, in addition to the French colonies, Siam and recently China have accepted the metric system, while Japan following England and North America has permitted a choice between the use of the metric and the national systems. In Africa, as far as the English influence extends, the English system is used. Egypt makes the metric system voluntary, the Union of South Africa gives it preference. In the French Domain the metric system has been firmly established. Australia is favorably inclined to the metric system, so that a uniform system of weights and measures in the inhabited portions of the globe will be in force shortly.

NEW INSTRUMENTS

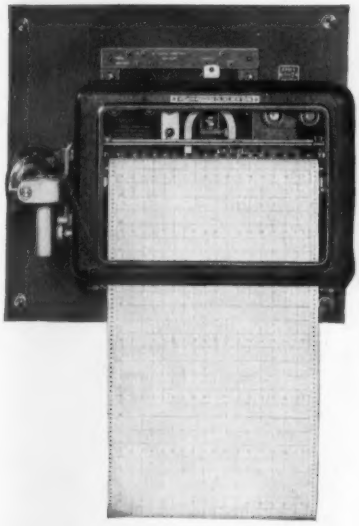
Recently Developed by Instrument Manufacturers

Write Information Section, Instruments Publishing Co., Pittsburgh, Pa., for additional information

New Potentiometer Pyrometer Recorder

A NEW Potentiometer Recording Pyrometer, developed by Wilson-Maeulen Company, has a temperature record chart 12″ wide, and shows a number of other new features of mechanical and electrical design.

In this potentiometer recorder, when the measured voltage from the thermocouple changes, as a result of temperature change at the thermocouple, the galvanometer pointer deflects in the corresponding direction.



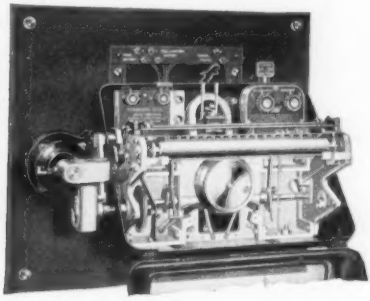


Fig. 1 (at left) Model 8201 Potentiometer Pyrometer.

Fig. 2 (above) Shows inside of Recorder.

At intervals of 10 seconds a boom descends and grips the pointer firmly while two sensing fingers, moving in a vertical plane, approach the pointer from each side, exploring for the location of the pointer, and if either finger finds the pointer deflected and away from its central or null position, a roller ratchet dog is released by the finger, causing a drum to turn.

By means of a violin string, wound around the drum and passing over pulleys at each side of the chart, and attached at opposite sides of a carriage, the motion of the drum in either direction is transmitted to the carriage which is adapted to travel back and forth across the

whole instrument. The carriage carries the pen which marks the chart in its travel, and a contact brush that rides on the potentiometer slide wire.

The selective operation of the drum's rotation, both in direction and extent, moves the contact on the slide wire so as to bring the galvanometer back towards its null or undeflected position, and at the same time moves the recording pen to record on the chart the temperature of the thermocouple.

Great width of chart, which provides a very open scale, and extremely legible printing of temperature lines and numbers on the chart, together with the bright and contrasting color of the ink used, makes it possible to read the chart at a considerable distance from the instrument.

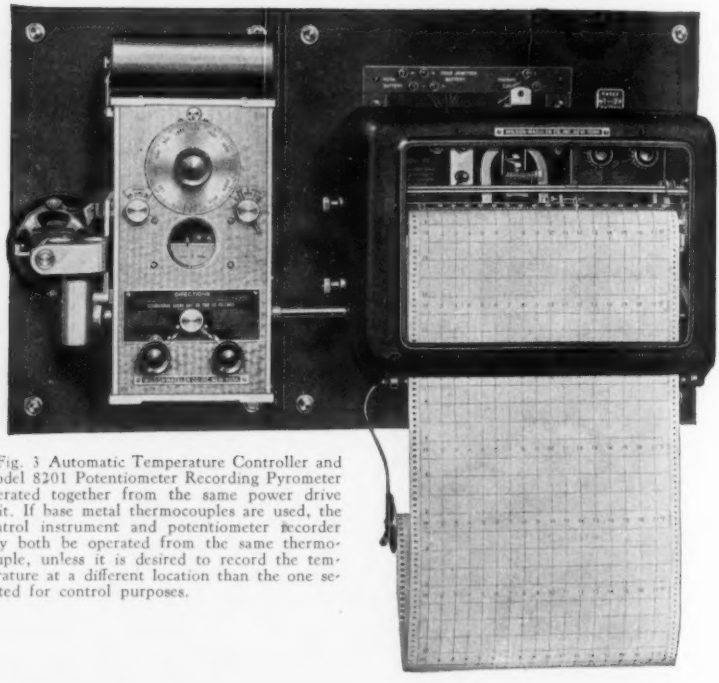


Fig. 3 Automatic Temperature Controller and Model 8201 Potentiometer Recording Pyrometer operated together from the same power drive unit. If base metal thermocouples are used, the control instrument and potentiometer recorder may both be operated from the same thermocouple, unless it is desired to record the temperature at a different location than the one selected for control purposes.

A choice of three chart speeds, namely ¾" per hour, 1½" per hour and 3" per hour, permits the user to secure the chart speed most suitable for his needs. On operations where temperature changes are slow and long periods of time are involved, the slow speed condenses the record and makes observation of trends and cycles easier. For rapidly fluctuating temperatures and short cycles of operation, the faster speeds allow more detailed analysis of temperature changes.

The recording pen and the slide wire contact are integral and cannot get out of relationship to each other.

The recording pen has a metal tube siphon that will stand cleaning and handling without breakage, and an ink reservoir that holds a supply of ink sufficient for an entire record roll. One of the interesting features is the ink developed by Wilson-Maeulen Company for this recorder. The ink has a brilliant red color and dries quickly on the record before the chart emerges from the case, so that the ink does not smear in passing through the paper slot.

Among the new advantages of this recorder is a provision for easily and quickly adjusting the sprocket at one end of the paper roller as to distance from the sprocket at the other end of the roller. This permits adjustment to accommodate for any variation in the width of the chart paper due to atmospheric conditions.

Changes in the temperature of the thermocouple cold junction are automatically compensated for in the instrument by an electric cold junction compensator, similar to the automatic compensators successfully used on all types of Wilson-Maeulen pyrometers for the past several years.

An external drive unit, consisting of an ample sized motor and double worm and gear speed reducing system, located outside the instrument case, furnishes power to the instrument mechanism.

This drive unit is identical with the drive unit satisfactorily employed on Wilson-Maeulen automatic temperature controllers for a number of years, and is supplied with this recorder for either 110 volts or 220 volts alternating current.

The drive unit provides ample power for operating more than one instrument, and the design is arranged so that a group of recorders, or a group combining this recorder and the Wilson-Maeulen automatic temperature control pyrometer, can be operated by one drive unit.

Charts are available for a wide selection of scale ranges, in both Fahrenheit and Centigrade scales, to suit the various types of thermocouples and to suit the various temperatures of industrial operations.

For low temperature operations, from 600°F. down to 0° F. or lower, this same recorder is supplied to operate as an electric thermometer employing resistance bulbs.

The instrument case opens diagonally, making the entire mechanism easily accessible. This accessibility includes the slide wire, which is wound on a straight rod, located in front just above the chart where it is easily cleaned. Slide wires are easily and quickly removed and replaced and are interchangeable.

Heavy and rugged construction and well machined parts are in evidence throughout.

One of the accessories obtainable is a storage roll and holder, which fits underneath the recorder, for rolling up and holding the used portion of the chart.

The wide chart of this instrument, its rugged mechanical construction, ample motive power and many other desirable features, make it of particular interest to industrial pyrometer users for all types of service.

Solenoid Valves

Packless Type

(*Electric Valve Manufacturing Co.*)

AUTOMATIC control is one of the most essential requirements in the industrial field. The best and least expensive means of automatic control of the flow of fuel to gas and oil burning equipments and of water, air, etc., is by means of a solenoid or magnetically operated valve governed by a thermostat, pressure regulator or float switch. These solenoid valves are made in two types commonly called the stuffing box or packed type and the packless type.

As it has been found that the packless type gives more satisfactory service than the stuffing box type, a number of solenoid valves of the packless type have been developed, descriptions of which are given in following pages.

Solenoid Movement. The solenoid movement is constructed so that the rustproofed steel plunger, which is directly connected to the stem of the valve, is allowed to slide in an air tight housing made of a special composition. This housing is sealed by means of a steel cap which is forced down with great pressure by a high tension spring. Due to rise in temperature of the solenoid under operating conditions an expansion of the cast iron housing takes place and this spring, which exerts a constant pressure on the top of the plunger housing, allows for this expansion, thereby keeping the plunger chamber leakproof under all conditions. The operating parts of the solenoid are rustproofed and the valve stem slides through a brass bushing so there is no occasion for the parts to fail to function through sticking. This movement is of a very sturdy construction so as to withstand frequent and numerous operations and is designed to take a standard ½" BX connection. Should replacement of coil, which is enclosed in cast iron housing, be desired, it is only necessary to remove the four cap screws which hold the cover in place. The coil can be replaced without disturbing any other part of the movement, thus eliminating the necessity of any readjustments.

The fluid to be controlled is allowed to flow into the plunger chamber without causing any injury to any part of the apparatus.

To provide ample power to operate the valves under various conditions and ranges of pressure, several sizes of solenoids are used.

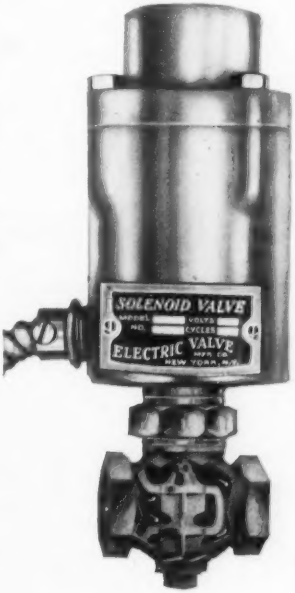
To provide for any industrial requirements, various types and sizes of packless valves can be used in connection with the several sizes of solenoids. Proper types of valves to meet special requirements can be adapted to these solenoid movements. The packless valve having no stuffing box can develop no leaks.

Operation. When circuit is made the magnet is energized, lifting the plunger to open the valve in which position it is retained as long as the current is left on. It will not overheat under continued service in the open position. Failure of the current causes the valve to close. The valve closes with the flow, thereby assuring tight seating.

It is actuated for remote control by push button or automatically by means of a two-wire thermostat, pressure regulator or float switch.

Relays. These solenoid valves can be operated direct from the lighting circuit as the power consumed is not any greater than can be taken care of by standard manually operated switching devices. Therefore, any standard push button can be used to operate these valves.

When solenoid valves are automatically operated by means of an instrument such as pyrometer, recorder or thermostat, which is usually provided with small contacts of the normally open, momentary contact, three-wire control type, these contacts not being able to carry the current that operates the valve, a relay must be interposed between the controlling device and the solenoid valve.



Type N Valve for Oil, Air, Water or Brine. This valve has a broad use in the industrial field and is especially designed to control feed supply to oil burning equipment and for supply of water on small water cooled refrigerating machines. It is also suitable for gas burning equipment where the valve is by-passed for a pilot or where a slight leak in seat is not objectionable.

The valve is of a needle type, the stem of which forms the needle that closes the valve. This stem is made with a 60 degree taper which is allowed to rest on the countersunk edge of a straight port, there being practically no wear on the seat due to

large angle of needle. Having no stuffing box and packing, the stem is allowed to slide freely without any friction. Therefore, the valve will not stick in either opened or closed position which makes it positive in action and fully dependable. It has a 1/4" or 3/8" port opening and can be furnished to accommodate 1/4", 3/8" or 1/2" pipe sizes. The pressure being admitted above the seat tends to force the stem down on the port and after a few operations the stem forms its own seat, thus assuring a tight seating.

Type D Valve for Oil, Water, Gas, Brine or Air. The valve is a globe valve of the removable disc type and either hard or soft disc made of various compositions can be used according to the nature of the fluid to be controlled. The disc rests on a rounded seat which together with tension of spring and actual working pressure which is applied above the disc, exerting a pressure on the seat, makes the valve absolutely tight seating. The pressure being admitted above the seat tends to hold the valve closed against the pull of the solenoid and is recommended only for moderate pressures in small sizes and low pressures in large sizes. Having no stuffing box and packing, the stem is allowed to slide without friction and will not stick in either open or closed position, which makes it positive in action and fully dependable.

Discs of different compositions are installed in this type of valve in order to take care of special requirements. Should valve be required to control flow of water, disc of suitable composition for this purpose is installed. Should requirement be for gas control, a disc of a different composition is used, etc. Renewable discs can be furnished for any fluid.

Type SB Valve for Water, Brine, Air or Oil. The type SB valve is a double bevel disc, semi-balanced valve suitable for moderately high pressures. This is a packless type of valve and is especially recommended where tight seating is not required.

Type P Valve for Steam, Oil, Water, Gas, Air, etc. The valve is of a double disc piston type and is fully balanced as the force exerted by the pressure upon the two discs, which are of the same area, is equal. The form of the valve chamber is such that it gives full area and offers no obstruction to flow through the valve.

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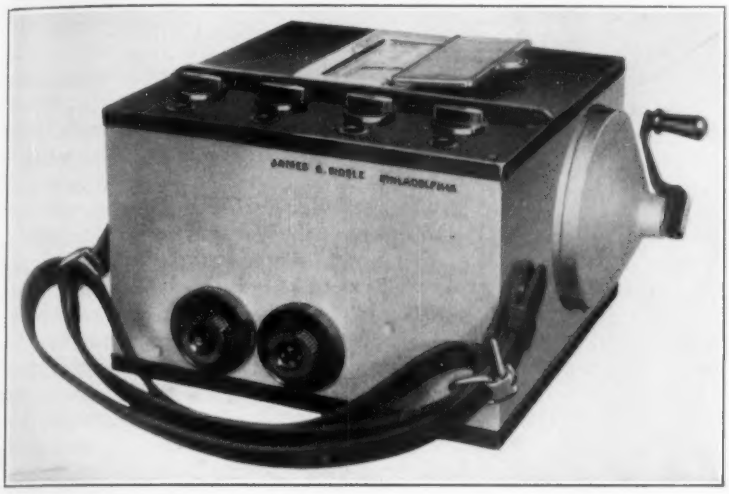
New "Megger" Instrument

FOR measuring resistance from .01 ohm up to 100 megohms (100,000,000 ohms), James G. Biddle is offering a new "Megger" instrument called the "Bridge-Meg" Resistance Tester. This instrument combines in one unit facilities for making Wheatstone Bridge measurements of conductor resistance at 250 volts, and also "Megger" tests of insulation resistance at 500 volts. It weighs only 12¾ lb., and measures 7 x 8¾ x 12 inches. It includes necessary dial resistances for "Bridge" tests, a direct-reading ohmmeter for "Megger" tests, and a 500-volt d.c. constant-pressure hand generator for current supply.

The range of measurement covered by the "Bridge" is from .01 ohm up to 999,900 ohms and the "Meg" (or "Megger") range is from 10,000 ohms up to 100 megohms. The "Meg" portion of the set is

similar to Biddle's "Meg" and "Super-Meg" Insulation Testers—direct reading by means of a pointer over a scale when connections are made and the hand-crank is turned. The "Bridge" arrangement has four dials of nine coils each in the resistance arm, giving a total of 9999 ohms. A five-position ratio dial (÷100, ÷10, ×1, ×10 and ×100) gives the

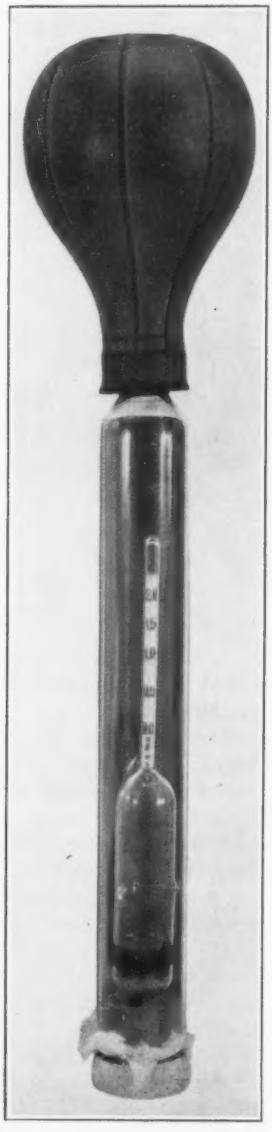


added breadth of range down to .01 ohm and up to 999,900 ohms. As a "Bridge" it is operated in the same way as an ordinary Wheatstone Bridge Set except that instead of employing a battery, current at 250 volts is supplied by the hand generator, and the ohmmeter is used as a galvanometer for balancing. Balance can be obtained quite rapidly by manipulating the resistance and ratio dials while the hand-crank is being turned.

There are only two binding posts, which are located on the side of the instrument opposite the hand crank. The change from "Bridge" to "Meg" and vice versa is made merely by turning a two-position dial. This and the ratio dial are shown near the base of the instrument in the picture. The "Bridge" rheostat dial positions are shown by numbers on discs which appear through small windows next to each dial. The case is of cast aluminum with bakelite top and base. A metal lid covers the "Meg" scale. A leather strap is provided for carrying.

An important feature of the hand generator is a slip-clutch arrangement by which a constant potential is delivered when the hand-crank is turned at or above its rated speed of about 160 r.p.m. This makes it possible to use the instrument as a "Bridge" under all conditions, including tests where a considerable amount of self induction is present —such as in large coils,—and also as a "Meg" for insulation resistance tests under all conditions including large apparatus and long cables where there is usually a considerable amount of electrostatic capacity.

The "Bridge-Meg" is designed and intended for practical everyday use by any one who needs to make rapid and accurate tests of resistance. It is rugged and practically fool-proof.



The assembled equipment is shown above. The calibration shown is in U. S. standard gallons per cubic foot, by tenths, and the range is from 0.0 to 2.0. Similar equipments are obtainable calibrated in lbs. water per 100 lbs. dry aggregate, for use where materials are batched by weight.

The Rapid Determination of Moisture in Damp Concreting Aggregates Without Computation

(*Tappan Collins*)

WITH concrete designed for a definite required strength, it has been repeatedly confirmed that a certain latitude in the measurement of aggregates is permissible, but that rigid control of the total hydrating water is indispensable.

Where materials are batched by volume, as is most commonly the practice, some variations in aggregate quantities are inevitable. If reasonable care is exercised to maintain even approximate compensation for variations due to bulking and segregation of unmixed aggregates, these inaccuracies are not in themselves excessively harmful. The experienced concrete foreman is prompt to detect "undersanding," or "oversanding," and handles its rough compensation quite as a matter of course.

With the more important variable, namely: fluctuations in the moisture content of the aggregates, he is altogether at sea. If the amount of contained moisture were known to him in gallons of moisture per cubic foot, for each aggregate, compensating the measuring water tank to deliver the correct total mixing water would be as simple and as readily handled as correcting for over—or undersanding.

It is the function of the Collins Hydrometer to measure this contained moisture and reveal the reading in gallons per cubic foot, without delay and without computation.

A quantity of saturated solution of common salt in water is kept on hand in a barrel or other convenient container near the batching operations, where control properly belongs, to insure that its temperature will approximate that of the aggregates. The specific gravity of this solution will remain almost exactly constant regardless of temperature changes, providing saturation is maintained.

If a volume of damp aggregate is mixed with an equal volume of saturated salt solution, all of the free moisture in the aggregate is promptly drawn into the solution, diluting it to a degree depending on the degree of dampness of the aggregate sample. It makes no difference how large or how small the sample volume is, or whether we know its size, so long as the volumes of sample and solution are equal.

At stated intervals, or when fluctuations in the moisture content are suspected, a small pail of saturated salt solution is placed in a mixing bucket and an equal volume of damp aggregate mixed with it. The resulting dirty solution is sampled with the filtering syringe containing the hydrometer and the moisture content is read directly from the scale in gallons per cubic foot.

The same test is useful for both fine and coarse aggregates. The instrument is easily cleaned and cannot possibly get out of adjustment. Saturation of the solution medium is maintained by keeping an excess of undissolved salt in the bottom of the container, and this saturation is readily checked by testing with the hydrometer for a zero reading.

Percent voids are similarly determined with the hydrometer, mixing one struck volume of inundated aggregate with two volumes of saturated salt solution. The resulting solution is tested with the hydrometer and the reading multiplied by 2 to obtain voids expressed in gallons of void per cubic foot of aggregate. To reduce this figure to percent voids, multiply by 13.362.

For those jobs where weighing batchers are used the hydrometer is furnished calibrated in pounds water per hundred pounds dry aggregate. In this case equal weights of aggregate sample and solution medium are employed, and a crude spring balance suffices for precision weighing since equating the weights cancels any error inherent in the balance.

These instruments are individually hand-calibrated and are guaranteed not to depart from the specified specific gravity equivalents more than half of the least scale division at any point on the scale. Both the method and apparatus are covered by applications for letters patent.

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New Precision Potentiometer

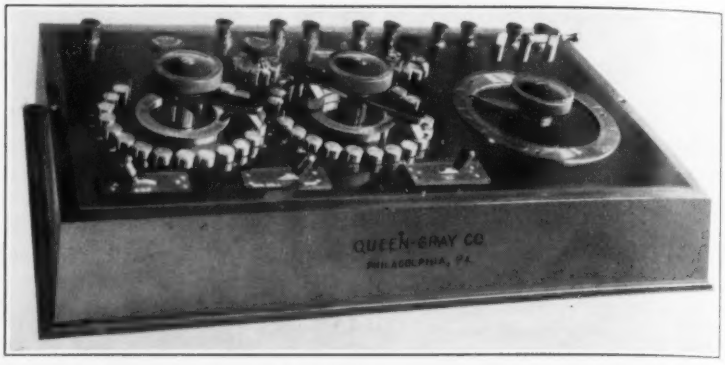
(*Gray Instrument Company*)

THE very important place which the potentiometer now occupies among electrical measuring instruments, especially for the precise measurements of electromotive forces, has increased its field of usefulness.

In Standardizing, Physical, Biological, Chemical and Physiological Laboratories, the potentiometer is regarded as essential.

The potentiometer is essentially an instrument for comparing differences of potential and the various designs differ in the method of dividing the potential drop into decimal steps. Such instruments have either high or low resistance circuits, and while each possesses inherent advantages it also presents disadvantages. The high resistance potentiometer requires a very small amount of current so that a long series

of measurements can be made without the necessity of readjusting the current in the potentiometer circuit. It, however, involves a larger number of switches for manipulation to establish a balance and is there-



fore not so convenient to manipulate in addition to its higher cost. In low resistance potentiometers the current required is larger and variation in resistance, especially of the battery, will vary the current to an appreciable extent, thereby necessitating more frequent adjustment of the regulating rheostat and consequent repeated checking against the standard cell to insure the correctness of the E. M. F. under test.

The low resistance type eliminates the use of contacts directly in the potentiometer circuit, thereby confining it to the use of only one series of resistances and a slide wire. It has the advantage of greater convenience of manipulation as compared with the high resistance potentiometer.

This potentiometer combines accuracy, range and facility for the most exacting measurements in potentiometry. The circuit is the "split" type thereby enabling the last setting to be made on a single turn of slide wire, the contact of which is continuously rotatable. This feature avoids turning back over the wire for setting to zero making for quick settings and eliminating unnecessary wear.

The direct range is 0.000001 volt (1 micro-volt) to 1.811 volts which can be extended by external multipliers. The instrument is complete with regulating rheostat for any type of battery and a standard cell setting control to permit the use of any Cadmium cell.

The setting key for the E. M. F. and the standard cell circuits is of the lever type as is also the galvanometer circuit key with its protecting resistances. This form of key is characterized by a convenience and freedom from derangement not equalled by any other construction.

The total circuit resistance is intermediate between high and low resistance potentiometers thereby embodying the advantages of each of these forms without their disadvantages.

The current required is but 0.002 ampere and in service this potentiometer can be used over long intervals without the need to check back on the standard cell or to make readjustments of the regulating rheostats.

Tetco Tim Seven Day Operation Recorder

(*Electric Tachometer Corporation*)

VARIOUS types of "Operation Recorders" have been on the market for years and proven a very valuable asset in industrial plants to record the productive and non-productive time of various types of automatic and stationary machines.

Heretofore, recorders of this nature were furnished with 24-hour charts necessitating the changing of charts within 24 hours or the record

HALF SIZE

for the previous day would be spoiled. The Tetco Tim recorder on the other hand, is provided with an automatic daily trip mechanism, so that a new record is made each day. These records cannot interfere with one another as shown on the chart above. The Seven Day record remains intact. Another advantage of the seven day feature is that charts can be removed at any time during the week. The Record is, therefore, suited for either single or seven day operation. The clock requires winding once per week.

The use of a seven day recorder will save several dollars per year in the cost of charts alone. The time required to wind the clocks and install charts is reduced to once per week instead of daily. This makes Tetco Tim recorders very economical to use.

The Tetco Tim recorder operates on the same principle as previous types, namely motion produced by the machine in operation. This means no driving details or electrical connections are required. The recorder is simply bolted fast to some slow moving part of the machine such as cam shafts, plungers, etc. They can be mounted direct on rotating machines or wheels provided the speed is not more than 60 RPM. These recorders will show the time in operation by a heavy line and idle time by a light line. All starts and stops are easily detected from the chart.

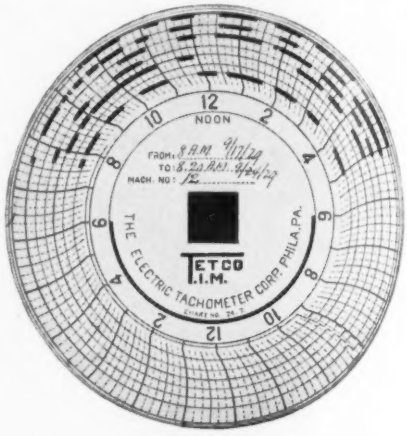


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Chart inserted 8:00 A.M.
Chart removed 8:20 A.M. one week later.
Change over at 9:15 P.M. each day.

As a Production Recorder, it will show the time the machine starts each morning and any stops due to poor material or inefficient operators. This gives a very thorough analysis of machine operations and will greatly increase the production of machines equipped with them.

No ink, pencil or troublesome writing mechanism is used in these recorders. They employ a special wax coated chart which will stand rough handling. A steel stylus is fastened to the writing arm, which in turn, is operated back and forth through the swinging of the pendulum. The pendulum being at rest when there is no motion, a narrow line is produced showing idle periods. When the machine upon which the recorder is mounted is operating, the pendulum starts oscillating and a wide line is produced.

The recorder is very compact. It is approximately 6″ in diameter and weighs 2½ lbs. The front is provided with a clock dial to enable the recorder to serve two purposes. In special cases where a number are used in the same room or if, for any reason, the clock dial is not desired, the recorder can be supplied with a cover plate over the clock. A "slow and fast" adjustment is provided for the clock. Each recorder is furnished with a substantial lock and duplicate keys.

Since these recorders are operated by motion, they can be used to check idle or operating time on all kinds of vehicles, tractors, cranes, hoists, etc.

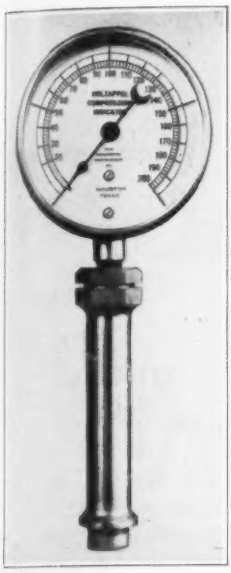
——— :: ———

New Compression Indicator

(*G. L. Holzapfel*)

THE high compression pressures used on modern internal combustion engines have made all the more important the maintaining of the designed pressure and emphasize the importance of an accurate gauge

for testing that pressure. Hitherto, the employment of comparatively low compression pressures rendered their periodic measurement less necessary and as a result only one or two gauges were on the market, most of them inaccurate, all of them inconvenient.



Compression pressure can be affected by badly seating valves or leaky pistons; piston leaks are usually due to gummed rings or to wear, but in the majority of cases compression leaks are due to faulty valves.

When compression begins to leak past the valves, burning takes place rapidly and both valve and seat become permanently damaged, the degree of damage depending upon the time during which such leakage takes place. Gummed rings may cause serious scoring of the cylinders. All piston leaks cause dilution of lubricating oil and serious wear of pistons, cylinder walls and engine bearings.

Apart from this, compression leaks cause considerable loss of power and consequent wastage of fuel and oil, besides making the car very much less pleasant to drive.

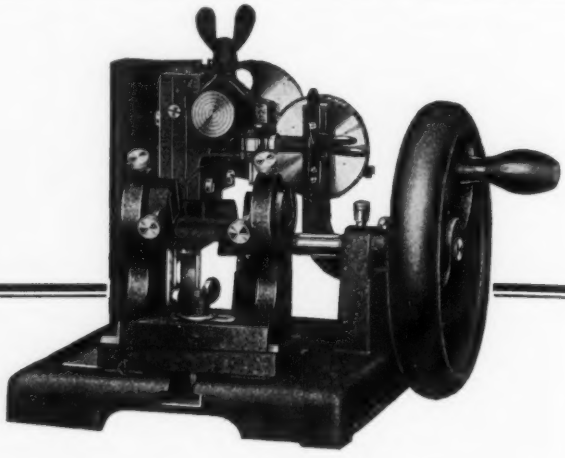
Even experts cannot tell, without making accurate measurements, when small leaks are taking place and thus deterioration begins before its effect can be felt. Timely use of the Holzapfel Compression Indicator will prevent such deterioration, for with it all leaks can be determined in their early stages.

The Holzapfel Compression Indicator has been recently designed to fill the need for an accurate and reliable instrument. All existing instruments were carefully tested and their objections overcome, and an instrument produced having none of the disadvantages of the others.

The compression indicator is screwed into the spark plug orifice and the engine cranked (about five turns are sufficient to reach the maximum pressure). It can be plainly seen that, owing to the action of the check valve, the pressure of the gas pumped into the space communicating with the pressure gauge very soon reaches the maximum pressure reached in the engine cylinder during the compression stroke, this pressure being, of course, registered on the pressure gauge.

The check valve is so designed that it is absolutely gas-tight, so that the compressed gas trapped in the upper part of the body is held there, recording the maximum compression pressure, until released by the depression of the valve.

It will be seen that this gauge overcomes all of the difficulties previously experienced. There are no inertia effects, it functions in the shortest period of time, it is self-recording and extremely simple in operation. The valve can be replaced in a few seconds and the simplicity of the instrument is the reason for its absolute reliability.



Minot Simplified Automatic Rotary Microtome

MODIFICATIONS of the Standard Rotary Microtome sponsored by the late Dr. Charles S. Minot of Harvard University consist of the essential features of the type made by the International Instrument Company and approved by Dr. F. B. Mallory of the same institution.

Four of its outstanding features are:

1. The Universal ball and socket specimen clamp with one screw only for prime rigidity.
2. The vertical and horizontal bearings are fitted with high grade steel inserts, contacted by screws conveniently placed to provide means for taking up wear when necessary.
3. A cog wheel of steel feeds two microns at a time.
4. The base is very heavy to give great stability in use.

Write for complete information on this model.

Bausch & Lomb Optical Co.

637 St. Paul St. Rochester, N. Y.

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AUDIO FREQUENCY TRANSFORMERS. This booklet describes audio frequency transformers, choke coils and other equipment for radio receivers and accessories. Ferranti, Inc., 130 West 42nd St., New York, N. Y.

BALANCES. Various laboratory and dispensing balances are illustrated in this leaflet. Torsion Balance Co., 92 Reade St., New York, N. Y.

BAKELITE REVIEW. The October issue illustrates a number of applications of Bakelite. Bakelite Corporation, 247 Park Ave., New York, N. Y.

CONTROL OF WATER CONSUMPTION. This leaflet SH 3119 briefly considers the use of Siemens & Halske Venturi Meters. This is printed in English. Siemens & Halske A.-G., Berlin-Siemensstadt, Germany.

DO YOU THINK THAT LUCK IS AGAINST YOU? Reprint from the American Magazine gives a biography of J. J. Bausch. Bausch & Lomb Optical Co., Rochester, N. Y.

DIESEL ENGINE INDICATORS. Circ. 1a illustrates "Super" diesel engine indicators. Dobbie McInnes & Clyde, Ltd., 57 Bothwell St., Glasgow, Scotland.

DELINEASCOPES. Leaflet describes and gives prices of Spencer delineascopes. Spencer Lens Company, 19 Doat St., Buffalo, N. Y.

DISTANCE PRESSURE METER. Leaflet SH 2747 illustrates the distance pressure meter, and discusses application. This is printed in English. Siemens & Halske, A.-G., Berlin-Siemensstadt, Germany.

THE ENGINE INDICATOR. This small booklet discusses the commercial value of engine indicators and gives instructions for use. Dobbie McInnes & Clyde, Ltd., 57 Bothwell St., Glasgow, Scotland.

FREQUENCY METERS. Circ. 9851g-G 70-1029 illustrates industrial frequency meters accurate to within 0.1 cycle. Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

GENERAL CATALOG. The Foxboro Company has issued a binder containing new bulletins on instruments for indicating, recording and controlling temperature, pressure, humidity, volume and flow. The Foxboro Co., Foxboro, Mass.

GENERAL BULLETIN. Bulletin 12 lists the products manufactured by the Bailey Meter Company, 1050 Ivanhoe Road, Cleveland, O.

GAS SERVICE JOURNAL. The September issue contains the following: The Pittsburgh Equitable Engineering Department; New Method Used in Annealing Malleable Iron; History of Discovery and Use of Natural Gas at Muskegon, Michigan; The Romance of Colonel Drake; and Mercury and Its Purification. The October issue contains the following articles: Natural Gas Development in Utah; Refueling the Graf Zeppelin; and Natural Gas for El Paso, Texas. Pittsburgh Equitable Meter Co., 400 Lexington Ave., Pittsburgh, Pa.

GRAVITY GRADOMETER. Reprint from the Oil News entitled "Evolution of the Eotvos Torsion Balance." Improvements made on instrument described. L. Oertling, Ltd., 65 Holborn Viaduct, London, E. C. 1, England.

GENERAL RADIO EXPERIMENTER. The September issue has the following articles: Improving the Precision of Setting in a Tuned-Circuit Wavemeter and a Radio Frequency Driver for the Service Laboratory. General Radio Company, Cambridge, Mass.

GENERAL CATALOG. Catalog No. 4 has 160 pages covering "Everything for Mine and Industrial Safety." It is subdivided into the following general classifications: Edison electric safety cap lamps and accessories, permissible shot firing devices, Wolf flame safety lamps, gas and air measuring devices, rock dusting equipment, oxygen breathing apparatus, a complete line of gas mask respiratory protective equipment, gas detectors and recorders, resuscitation equipment, eye and head protective equipment, safety clothing, safety saws and a complete line of first aid supplies. Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

GAS METERING APPARATUS. Leaflet 3161 lists various gas measuring instruments. Siemens & Halske A.-G., Berlin-Siemensstadt, Germany.

HYDROGRAPHIC INSTRUMENTS. Leaflet announces four new Stevens Hydrographic Instruments. Leupold, Volpel & Company, 267 Washington St., Portland, Oregon.

INDUSTRIAL REGULATORS. Folder contains new bulletins on Industrial Regulators. The bulletins are classified under three major headings: I. Industrial Motor Valves, II. Temperature, Pressure and Combustion Controllers, III. Automatic Control for Unit Heaters. Minneapolis Honeywell Regulator Company, Minneapolis, Minn.

ILLUMINATED CONNECTION DIAGRAMS FOR THE PROTECTION OF ELECTRICAL INSTALLATIONS. Reprint of an article appearing in the Siemens-Schukert Review. SH 2934. Siemens & Halske A.-G., Berlin-Siemensstadt, Germany.

INVESTIGATION OF IMPACTS IN AUTOMOBILE TRUCKS. Reprint of an article appearing in the Automobiltechnische Zeitschrift covers instruments for making the measurements. This is printed in German. Lehmann & Michels, Hamburg-Altona, Germany.

INSTRUMENT INVESTMENT NEWS. The October issue contains the following: What Power Control Can Mean; Why the Hancock Cone Seat Valve Is Most Economical; Versatility of Dairy Recorders and Practical Farm Aid. Consolidated Ashcroft Hancock Company, Inc., Bridgeport, Conn.

LABORATORY GUIDANCE FOR EVERY CYCLE. Circ. 169-P 20-929 illustrates the application of the L & N potentiometer to checking superheater temperature in gas plants.

LATHES. Bulletin 9 covers new model 9" lathe. Practical attachments for adapting it to milling, keyway cutting, and grinding are also described and priced. Bulletin 22 covers new model 9" Junior lathe designed particularly for use in the small shop. South Bend Lathe Works, 409 E. Madison St., South Bend, Ind.

LIMUTER. Bulletin describes a device used to cut off the high peaks of the electric power demand. Steelcity Furnace Company, Pittsburgh, Pa.

MICROSCOPES. Catalogue of 103 pages covering Microscopes and Accessories. C. Baker, 244 High Holborn, London, England.

MANUFACTURED WEATHER IN THE PRINTING AND LITHOGRAPHIC INDUSTRIES. This 70 page book discusses the importance of humidity as applied to the printing and lithographic industries. Carrier Engineering Corporation, Newark, N. J.

MICROSCOPE RECORD. The September issue contains: Current Microscopy; The Microscopy of Rayon; The Rotifers of Bogs and Boggy Pools; Hints to Beginners; The Collection and Preparation of Diatoms; The Romance of Pond-Hunting and Setting Up the Microscope for Dark-Ground Illumination. W. Watson & Sons, Ltd., 313 High Holborn, London, W. C. 1, England.

MECHANICAL PYROMETER. Leaflet describes a new mechanical pyrometer. E. J. Chubbuck Company, 4595 Horton St., Emeryville, Calif.

METEOROLOGICAL INSTRUMENTS. Leaflet 20 illustrates and describes a number of meteorological instruments: barometers, hygrometers, maximum and minimum thermometers, hair hygrometer, hyrograph, aneroid barograph, thermograph, rain and snow gauges, sunshine recorders and cup anemometers. Colonial Supply Company, 217 Water St., Pittsburgh, Pa.

MERCOIDS. The October issue of the house organ has several interesting articles on Mercoid controls. Mercoid Corporation, 564 W. Adams St., Chicago, Ill.

PROTECTING AN INVESTMENT OF MILLIONS. Bulletin 929 considers the applications of speed recorders to turbo-generators, and pressure recorders to hydraulic plants. Esterline-Angus Company, Indianapolis, Ind.

INSTRUMENTS OF PRECISION. Catalog M-130 lists reading microscopes, micrometer microscopes, microscope supports and accessories. 80 pages. Gaertner Scientific Corporation, 1201 Wrightwood Ave., Chicago, Ill.

PAPER STRENGTH AND STRETCH TESTER. Bulletin describes and illustrates the Schopper rapid strength and stretch tester. Results on several papers are given. H. Z. Schniewind, 72 Duane St., New York, N. Y.

PRESSURE AND DRAFT CONTROL. Leaflet SH 3147 describes pressure and draft tele-recording gages. This is printed in English. Siemens & Halske A.-G., Berlin-Siemensstadt, Germany.

REVOLUTION COUNTERS. Catalogue 1 covers portable revolution counters and a stop watch. Colonial Supply Company, 214 Water St., Pittsburgh, Pa.

RADIO TESTING INSTRUMENTS. The following items are included in the instruments described in this bulletin: D. C. Voltmeters, D. C. Ammeters, Thermaltype, Rectifier Type, Micro-Ammeters, Pocket Test Sets and D. C. Tube Testers. Ferranti, Inc., 130 West 42nd St., New York, N. Y.

RUBBER HARDNESS TESTER AND PLASTOMETER. Folder 371 describes instruments for determining the hardness of rubber, vulcanite, insulating materials, etc. H. Z. Schniewind, 72 Duane St., New York, N. Y.

SOLENOID VALVES. Bulletin 100 covers packless type valves for oil, gas, water, air, etc. Bulletin 117 covers valves for automatic or remote control. Electric Valve Mfg. Co., 68 Murray St., New York, N. Y.

SELSYN OPERATED DEVICES. Selsyn Operated Devices for Remote Indication and Record of Liquid Level, Flow, Pressure, Temperature, Draft, Position and Other Factors, is the title of Bulletin 110. Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.

TYCOS ROCHESTER. The October issue of Tycos Rochester contains the following: Nature's Own Weather Bureau; The Famed Equinoctial Storm; Relative Humidity as an "Index of Comfort;" Weather Service for Aviation; Tropical Cyclones and Their Effect; Birds Are Equipped with Good Heat Engines; Taking the Temperature of Insects and The Birthplace of Icebergs Explored. Taylor Instrument Companies, Rochester, N. Y.

TIME RECORDER. Bulletin 134 describes an instrument for recording the operative and idle time of motor vehicles, locomotives, cars, etc. Electric Tachometer Corp., Broad and Spring Sts., Philadelphia, Pa.

TECHNICAL INSTRUMENT BULLETIN. The September issue of this house organ contains: Artificial Reflectors in Microscopy with Reflected Light; A Few Hints On Projection, Micro-Projection and Photo-Micrography. New Projection Drawing Apparatus. Emil Busch Optical Co., Hatton Garden, London, E. C. 1, England.

VIBRATION IN MACHINERY. Reprint from Die Werkzeugmaschine which reports investigations of vibration in machinery. This is printed in German. Lehmann & Michels, Hamburg-Altona, Germany.

VIBROMETER. Leaflet illustrates the K B B vibrometer and discusses its scope. Kelvin Bottomley & Baird, Ltd., 18 Cambridge St., Glasgow, Scotland.

CHRONOGRAPHS. Folder contains leaflets describing various chronographs. These are printed in German. H. Wetzer, P fronten, Germany.

THERMOMETER. Leaflet illustrates the Motoco indoor and outdoor thermometer. Motometer Gauge and Equipment Corp., Long Island City, N. Y.

RECORDING GAS CALORIMETER. Bulletin 108 illustrates the Johnson Recording Gas Calorimeter. Gas Producer & Engineering Corp., Coatesville, Pa.

THERMIONIC VOLTMETERS. List 911 describes various types of thermionic voltmeters. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

OSCILLOGRAPH. List 918 illustrates and describes the Duddell Oscillograph. Cambridge Instrument Co., Grand Central Terminal, New York, N. Y.

GAS MEASUREMENT ENGINEERING. This is a new publication published from time to time as a record of noteworthy activity relating to gas meters and allied apparatus. The first number appeared in May, 1929. The second issue which appeared in October illustrates the refueling of the Graf Zeppelin. American Meter Co., 105 West 40th St., New York, N. Y.

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THE Weston "Junior" Line embraces D. C. and Single Phase Wattmeters, A. C. Ammeters and Voltmeters and Current and Potential Transformers. Wattmeters, Ammeters and Voltmeters are enclosed in durable black bakelite cases, fully shielded from stray magnetic fields. They are supplied with knife-edge pointers and mirror scales, and every feature of construction is of highest Weston quality. Decidedly popular in every field of electrical testing—Industrial, Railway, Factory and Field Inspection Work, Laboratory and Educational Institutions.

WESTON ELECTRICAL INSTRUMENT CORP.
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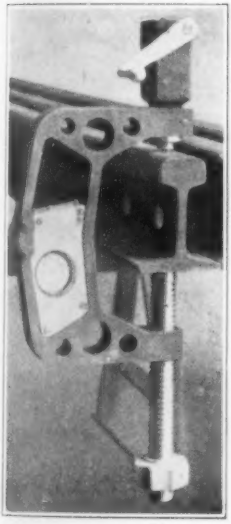
New Portable Brinell Tester



Permits Making Hardness Tests in the Shop, Storeroom and Field

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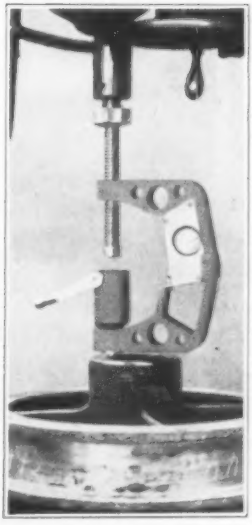

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CURRENT LITERATURE REVIEW

Abstracts on instruments and devices for measurement, inspection and control.

The Technology Department, Carnegie Library, Pittsburgh, Pa., will furnish photostats of material abstracted here. Negative prints are 35 cents per page, plus 10 cents for mailing (first class). All orders should be paid in advance. The library is not responsible for loss in mails.

Scientific Examination of Documents and Works of Art. A. Maché. Rev. franc. phot., May 15, 1929, pp. 145-147; June 1, pp. 161-166; June 15, pp. 182-184; July 1, pp. 198-199.

A general survey of means of detecting falsity of checks, bank notes, postage stamps, antiques, paintings, synthetic stones, and pearls, etc. Reference is made to photographic examination of paintings.—Abs. Bull. Kodak Res. Labs.

New Camera to Test Performance of Airplanes in Flight. H. C. McKay. Photo-Era, July 1929, p. 58.

A machine-gun motion picture camera makes 300 exposures per second, and by means of a network of lines covering the image, it is possible to make a number of calculations of great value to the designer of airplanes.—Abs. Bull. Kodak Res. Labs.

Photomicrographs of Rock Sections in Polarized Light. Valliere. Bull soc. franc. phot., April 1928, pp. 89-90.

The author has employed polarized light (obtained by the use of a pile of sheets of glass) for making Autochrome photomicrographs of rock sections. He used a solution of uranyl nitrate for a filter.—Abs. Bull. Kodak Res. Labs.

Testing Insulation Resistance. C. Sylvester. Kinemat. Weekly, June 27, 1929, p. 78.

Insulation resistances of circuits and electrical apparatus are tested by means of a voltmeter.—Abs. Bull. Kodak Res. Labs.

Measurement of the Strength of Sunlight. J. E. Moss and A. W. Knapp. Analyst, June 1929, pp. 334-335.

A criticism, on theoretical grounds, of the potassium iodide method of estimating the quantity of ultra-violet radiation. A solution of uranium acetate and oxalic acid is preferred.—Abs. Bull. Kodak Res. Labs.

Investigation of the Methods Employed for the Determination of the pH Value of Tan Liquors and Lime Liquors. W. B. Pleass. Jl. Soc. Chem. Ind., June 28, 1929, pp. 152-156T.

The methods for the determination of the pH value of liquids are classified and the qualities of each examined for the particular cases of tan liquors and lime liquors. The comparator colorimetric method is avoided because of the inconvenience involved in preparing accurately standard buffer solutions. The capillator colorimetric method, suitable for use with buffered liquids, is simple, rapid, and reliable. With tan liquors, it usually gives results correct to within 0.2 pH unit, but cannot be used with lime liquors since no indicator is available for this range of pH values. The hydrogen electrode gives accurate results in most instances, but is affected by the presence of substances giving rise to an oxidation-reduction potential, such as sulfites and sulfides. The quinhydrone electrode was unreliable for all the trade tan liquors examined. The glass electrode method is described, and is stated to be the best for use with liquors of unknown constitution. It is accurate and reliable for tan liquors and lime liquors from pH 1 to pH 13, and is unaffected by sulfites and sulfides.—Abs. Bull. Kodak Res. Labs.

"Controllable" Slip Abrasion Machine. P. Schidrowitz. India Rubber Jl., March 16, 1929, pp. 401-405.

The machine consists of a motor of controllable speed which drives the rubber test piece, in the form of a wheel, under a definite load against an abrasive wheel on which a brake is operated. The speed of both the test wheel and the abrasive wheel can be read at any time by means of tachometers. The amount of slip can therefore be calculated and controlled.—Abs. Bull. Kodak Res. Labs.

New Physical Test for Vulcanized Rubber. D. D. Wright. India Rubber Jl., May 25, 1929, pp. 9, 10-12.

The new test is known as a tongue shear test. A rectangular test piece is slit into 3 approximately equal strips for about 2/3 of its length. In the test the center strip is drawn downward while the strips at the side are held apart at a definite angle. The top of the test piece is held in the upper jaw of the testing machine. Any standard testing machine may be used. The combined tearing and stressing effect is said to give a better indication of the extent of aging whether natural or artificial.—Abs. Bull. Kodak Res. Labs.

Temperature Control in Vulcanizers. C. B. Mitchella. Ruber Age, Feb. 25, 1929, pp. 547-548.

A general discussion of vulcanizer design is given. The main objects to be attained in the design of a vulcanizer are: To allow escape of air present in vulcanizer when the steam is turned on; to allow free circulation of the steam; to allow proper drainage of condensate; and by these means to prevent hot and cold spots in the vulcanizer.—Abs. Bull. Kodak Res. Labs.

A New Apparatus to Record Deflections of Unifilar and Bifilar Electrometers (Ueber einen neuen Apparat zur Registrierung der Ausschlaege von Ein-und Zweifaden-Elektrometern). O. Mathias and V. F. Hess. Physik. Zeits., Aug. 15, 1929, pp. 508-512.

This new modification of an old type recorder of Kolhoerster avoids all sources of error by adding the photograph of the scale of the micrometer to the picture of filaments. The instrument is described in detail and illustration given; it has been used especially for observation of cosmic ultra-radiations.—H.A.

(Current Literature Review continued on Page 14)

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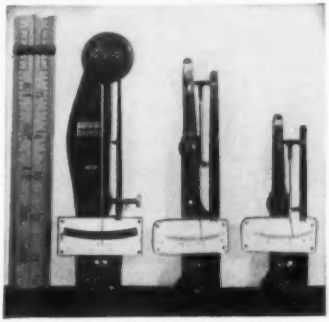

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CURRENT LITERATURE REVIEW

Simple Method for the Determination of Phosphorus in Coal Ash. W. J. Skilling and E. D. Ballantine. Jl. Soc. Chem. Ind., May 31, 1929, pp. 115-118T.

Rapidly performed and simple method of determining phosphorus in coal ash renders unnecessary fusion with sodium carbonate and the use of platinum vessels. Sulfuric acid is used in the digestion of the sample, and the molybdate solution recommended is that described in Scott's Methods of Chemical Analysis.—Abs. Bull. Kodak Res. Labs.

Analysis of X-Ray Spectroscopy. C. E. Eddy, T. H. Laby and A. H. Turner. Proc. Roy. Soc., June 4, 1929, pp. 249-268.

Owing to the simplicity of X-ray spectra, and emission of the practically complete spectrum at low percentages of concentration, analysis of metals for impurities by X-ray spectroscopy offers definite advantages. Technical difficulties, however, are very much greater than in optical spectroscopy. Details are given of various analyses and of the apparatus used.—Abs. Bull. Kodak Res. Labs.

Method for the Rapid Determination of Dust in Air. L. C. McNair and J. F. Herst. Jl. Soc. Chem. Ind., May 31, 1929, p. 127T.

Five to ten cubic feet of air is aspirated through a 4-cm. Gooch crucible packed with 5 grams of powdered cane sugar. Sugar and dust are washed with 20 c.c. of water into a centrifuge tube terminated by a capillary tube. From the volume of dust, its weight is computed.—Abs. Bull. Kodak Res. Labs.

Measurement of Jelly Strength of Gelatin. A. Lottermoser and W. Mathaes. Phot. Ind., May 15, 1929, pp. 531-533.

To obviate the errors and difficulties of the cylindrical type of plunger, a cone-shaped plunger is used. The instrument is described and data are discussed.—Abs. Bull. Kodak Res. Labs.

Thermoelectric Temperature Scales. Wm. F. Roeser. B. of S. Jl. Res., Sept. 1929, pp. 345-358.

The difference between four thermoelectric temperature scales based upon (1) Sb, Ag, and Au; (2) Zn, Sb, Ag, and Au; (3) Zn, Al, and Cu; and (4) Zn, Sb, and Cu as calibration points were determined. The maximum difference between (1) and (2) was found to be 0.1° C., between (1) and (3) 0.2° C., and between (1) and (4) 0.3° C. in the temperature range 660° to 1,063° C. The freezing point of the copper-silver eutectic alloy, 71.9 per cent silver and 28.1 per cent copper, on the International Temperature Scale was found to be 779.4° C. ± 0.1° C. The difference between the freezing points of gold and copper was found to be 20.0° C. ± 0.1° C. Methods used at the Bureau of Standards in realizing the International Temperature Scale in the range 660° to 1,063° C. are described in detail.

Effect of Oxidizing Conditions On Accelerated Electrolytic Corrosion Tests. Henry S. Rawdon and W. A. Tucker. B. of S. Jl. Res., Sept. 1929, pp. 375-390.

Accelerated electrolytic corrosion tests were made on sheet copper and nickel in a sodium-chloride solution. Both anode and cathode were of the same metal, and the applied emf was relatively very low; the results are expressed as loss-of-weight-potential curves. The effect of oxidizing conditions was studied by surrounding the cell by an atmosphere of oxygen or nitrogen and/or dissolving the same gas in the electrolyte. The results clearly show the accelerating effect of oxygen or corrosion by reducing the potential necessary for a given corrosion rate. The results also have a distinct bearing on the theory of underwater corrosion as affected by conditions of differential oxidation within the solution.

A Suppressed-Zero Electrodynamic Voltmeter. F. K. Harris. B. of S. Jl. Res., Sept. 1929, pp. 445-457.

An error is introduced into the reading of a deflecting instrument by inelastic yielding of the mechanism supplying the counter torque. This error, if large enough to affect precision, may be made negligible by keeping the instrument permanently deflected to one position and allowing only small changes in this deflection. For a voltmeter this procedure necessitates a variable multiplier which in turn introduces a special problem in temperature compensation. The present paper describes an attempt at the solution of these problems. The resulting instrument will measure alternating voltages between 20 and 300 volts at power frequencies to an accuracy of 0.01 per cent. An appendix discusses some difficulties encountered in obtaining a steady supply of alternating voltage and described the methods used in eliminating the troubles.

Temperature and Pressure Regulation. G. W. Tompkin. Facts About Sugar, Oct. 12, 1929, pp. 970-971.

Remarks on the application of automatic control in sugar factories.

The Technical Applications of Ultra-Violet Apparatus. J Mansel. Instrument World, Aug. 1929 pp. 105-106.

This, the concluding article, covers the testing of dye fastness, halogenation reactions and photosynthesis.—M.B.R.

Kinetic Boundary Friction. J. Wells. Instrument World, Aug. 1929, pp. 107-108.

The apparatus described is a device by means of which the coefficient of friction between 2 surfaces in contact can be evaluated.—M.B.R.

The Comparison of the Whiteness of Fabrics, Using a Cube Photometer. The Instrument and Its Uses. A. Adderley. Instrument World, Oct. 1929, pp. 157-161.

Reprint from August Journal of the Textile Institute. The paper describes an instrument which measures the whiteness of fabric.—M.B.R.

An Improved Differential Dilatometer. Max Haas and D. Uno. Instrument World, Oct. 1929, pp. 163-164.

Paper read at the Duesseldorf meeting of the Institute of Metals. This article describes a mechanical improvement to the optical differential dilatometer of Chevenard.—M.B.R.

(Current Literature Review continued on Page 16)

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CURRENT LITERATURE REVIEW

A Thermostat to Work Off A. C. Mains. John Hume. Jl. Opt. Soc., Sept. 1929, pp. 158-161.
A thermoregulator is described, which is convenient, reliable and easy to construct.—M.B.R.

A Simple Air Thermometer. J. Shrader. Jl. Opt. Soc., Sept. 1929, pp. 162-163.
The instrument is described and illustrated.—M.B.R.

Microscopical Examination of Glass. L. Springer. Instrument World, Aug. 1929, pp. 101-103.
Reprint from the Technical Instrument Bulletin, issued by Emil Busch Co.—M.B.R.

A Cinematographic Recording Galvanometer. S. Bayne-Jones and L. V. Foster. Jl. Opt. Soc., Aug. 1929, pp. 73-77.
This paper describes a means of obtaining a photographic record of the scale division reflected from the mirror of a galvanometer together with a simultaneous photograph of a watch-face to show the time of the photograph.—M.B.R.

A Pressure Controlled McLeod Gauge. N. Underwood. Jl. Opt. Soc., Aug. 1929, p. 78.
A gauge is described and illustrated which avoids the disastrous results caused by the vacuum going bad or not being properly controlled on either side of a vacuum controlled McLeod gauge. —M.B.R.

A Voltage Regulator for Gas Discharge X-Ray Tubes. F. Haworth. Jl. Opt. Soc., Aug. 1929, pp. 79-80.
This article describes a device used in connection with a gas discharge X-ray tube to regulate the voltage across it by automatically adjusting a mercury valve between the tube and the pumps, thus controlling the pressure of the gas.—M.B.R.

The Errors of Watt-Hour Meters at Small Loads and Low Power Factor (Die Fehler der Elektrizitaetszaehler bei kleinen Belastungen und niedrigem Leistungsfaktor). W. Fuhrmann. Messtechnik, Sept. 22, 1929, pp. 244-248.
This article considers: the relation of the error to the load and power factor; official determination of the errors; suiting of the meter size to the load; efforts to attain the largest possible power factor.

Hydraulic Occurrences and Relations with Current Meters (Ueber hydraulische Vorgaenge und Zusammenhaenge bei Fluegelradwassermessern). F. Schoniber. Messtechnik, Sept. 22, 1929, pp. 249-251.
The errors in current meters are discussed.

Graphical Time and Production Control by Means of Instruments (Schaubildliche Zeitaufnahmen und Leistungsueberwachung mittels betriebswirtschaftlicher Geraete). E. Oberhoff. Zs. Feinmech., Sept. 15, 1929, pp. 3-8.
Various operation recorders are described and illustrated.

Ellipse Compasses (Ellipsenzirkel). Dr. Albrecht. Zs. Feinmech., Sept. 15, 1929, pp. 8-10.
Compasses for drawing ellipses are described.

Electric Waves and Their Application to the Analysis of Crystal Structures (Elektrowellen und ihre Anwendung zur Analyse von Kristallstrukturen). E. Rupp. Zs. Feinmech., Sept. 15, 1929, pp. 11-15.
Article considers the nature of light, cathode rays, electron deflection, crystal analysis, structure analysis of the space lattice.

High Temperature Precision Measurements of the Properties of Solid and Liquid Substances. F. M. Jaeger. Sibley Journal of Engineering, June 1929, pp. 238-239, 278.
The article is a short survey of the author's work on the development of methods for the determination of physical constants of solids and liquids at higher temperatures.—M.B.R.

Viewpoints On the Choice of a Gas Meter (Gesichtspunkte zur Wahl eines Gasmessers). L. Litinsky. Messtechnik, July 22, 1929, pp. 183-189.
The article discusses the general considerations for the choice of type. The typical characteristics of the dry and wet meter are given and these two types of gas meter are compared.

Vacuum Gauge Investigations (Vakuummeteruntersuchungen). O. M. Faber and A. Wompener. Messtechnik, July 22, 1929, pp. 189-196.
Report of work done at the Weather Laboratory of the Mining Academy of Clausthal. The article gives a comprehensive survey of the various types of devices for measuring pressure below

The Measurement of Accelerations (Das Messen von Beschleunigungen). J. Geiger. Messtechnik, Aug. 22, 1929, pp. 211-217.
This article discusses the theory of acceleration measurement.
atmospheric used on condensors. The accuracy and suitability of several vacuum gauges is mentioned.

Standardized Charts in Boiler Operation (Genormte Diagrammpapiere im Dampfkesselbetriebe). H. Doevenspeck. Messtechnik, Aug. 22, 1929, pp. 217-220.
The article discusses the importance of boiler plant control, as well as the various types of charts: round chart, drum chart and strip chart. Suggestions for the choice of chart width and chart speed are given.

Viscosimeter for Liquids (Viskosimeter fuer Fluessigkeiten). W. Bueche. Messtechnik, Aug. 22, 1929, pp. 220-221.
A sample viscosimeter for the determination of the relation of the temperature and the viscosity. This instrument is placed in the oil similar to a hydrometer and slowly sinks into the oil, the speed of sinking is a measure of the viscosity.

Load Testers for the Calibration of Testing Machines (Kraftpruefer zum Eichen von Materialpruefungsmaschinen). O. Haberer. Messtechnik, Sept. 22, 1929, pp. 241-244.
Report from the Material Testing Laboratory of the Technische Hochschule Stuttgart. Several simple load testers designed by the author are described. Information on the calibration of the instruments is given.

(Current Literature Review continued on Page 18)

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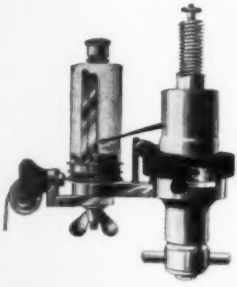

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Method for Production Control in Mineral Oil Refineries (Ueber eine Methode der Betriebskontrolle in Mineraloelraffinerien). H. Magnus. Petroleum, July 10, 1929, pp. 984-986.

A new Anseln-Hellige colorimeter is brought on the market with the object of continuously controlling the products of mineral oil refineries. The Stammer-Seybolt colorimeter as used in the U.S.A., England and Russia as well as the Hellige-Block comparator are included in the discussion.—E.F.

Analysis of Powdered Coal (Die Messtechnik auf dem Gebeite des Kohlenstaubes). C. Fourdreuther. Rauch und Staub, Jan. 1929, pp. 1-8.

The whole technique of analyzing powdered coal in laboratory and plant is outlined in regard to sampling, moisture, grain size, ash content, inflammability, chemical and calorimetric determinations on one hand and measurements of quantity, levels in storage, dust content in flowing mixtures, temperature, specific weight of stored powdered coal and tendency of caking on the other hand.—E.F.

Mechanical Solution of Oblique Angled Structures (Mechanostatische Bestimmung schiefwinkliger Tragwerke). O. Gottschalk. Beton und Eisen, March 20, 1929, pp. 113-119.

The Continostat intended for mechanical solution of static problems of frame structures instead of by calculations and complicated formulae is applied to oblique-angled structures.—E.F.

Compressive Strength, Bending Strength of Concrete with Varying Water Cement Ratios, Fineness Moduli and Largest Grain Sizes (Druckfestigkeit, Biegefestigkeit des Betons bei verschiedenen Wasserzementfaktoren, Feinheitsmoduli und groessten Korngroessen). M. Genel. Beton und Eisen, May 20, 1929, pp. 113-119.

Large scale laboratory tests based on methods according to Prof. Abrams, Chicago, and Prof. Graf, Stuttgart, are carried out to broaden knowledge concerning those factors which influence the physical properties of cement.—E.F.

The Watt Lux Meter (Das Watt-Lux Meter). E. Bausenwein. Lichttechnik, March 10, 1929, pp. 28-29.

The Watt Lux Meter, a portable, handy photometer, manufactured by the General Electric Co., is described.—E.F.

Remote Electrical Measurements with Particular Reference to the Trueb, Taeuber & Co., Induction System (Elektrische Fernmessungen mit besonderer Berucksichtigung des Induktionssystems von Trueb, Taeuber und Co.). A. Imhoff. Elektrotechnik und Machinenbau, March 10, 1929, pp. 189-192.

The principles involved in remote electrical measurements are outlined and a large number of practical examples are considered.—E.F.

New Methods of Fuel Examination (Neue Methoden der Brennstoffuntersuchung). Dr. Bunte. Gas und Wasserfach, Feb. 9, 1929, pp. 124-127.

The paper outlines all recently developed methods for the analysis of fuels. 23 references.—E.F.

Corrosion Tests with the Rust Apparatus (Korrosionsversuche mit dem Rostapparat). V. Duffek. Gas und Wasserfach, Feb. 9, 1929, pp. 127-129.

An apparatus for accelerated corrosion tests is described which in 24 hours determines corrosion attack of 4 months. The course of corrosion is recorded in diagrams wherein milliamperes are plotted against time. The manifold applications of the corrosion testing apparatus are outlined. —E.F.

Practical X-Ray Investigations (Technische Roentgenstrahlenuntersuchungen). A. Herr. Elektrotechnik und Maschinenbau, April 1929, pp. 329-332.

The present state of X-ray examination for routine testing is given by examples and the economy proven by calculations. The Laue method and structure diagrams are emphasized for inspecting commercial products.—E.F.

Installations for X-Ray Testing of Materials (Anlagen fuer Werkstoffpruefung mit Roentgenstrahlen). Dr. Painsipp. Elektrotechnik und Maschinenbau, April 21, 1929, pp. 333-337.

The equipment available on the market is reviewed and some practical features in regard to cost, radiation-proof protective screens and high tension protecting devices, etc., are discussed. —E.F.

Influence of the Apparatus Type On the Economical Use of X-Ray Tubes (Einfluss der Apparattype auf die Strahlungsausbeute der Roentgenrochre). J. Zakovsky. Elektrotechnik und Maschinenbau, April 21, 1929, pp. 337-341.

The different types on the market are compared and conclusions in regard to economical application are drawn.—E.F.

A Modern Method for Testing Materials in the Plant (Ein neutzeitliches Verfahren zur werkstattmassigen Prüfung von Werkstoffen). C. Lonanini. Werkstattstechnik, Sept. 1, 1929, pp. 495-496.

The most generally applied hardness tests, Brinell and Rockwell, are described, and the disadvantages, due to the errors of the subjective reading, are mentioned. The described Gerber hardness tester eliminates this by applying a direct load of weights and an automatic registration of the depth of indentation. The new apparatus can also be applied to Brinell and Rockwell tests.—G.N.

Regulo Pyrometer Controller (Regulo—Pyrometer Regler). Werkstattstechnik, Sept. 1, 1929, pp. 512-513.

The described instrument, built by G. Kromscheider A-G. Osnabrück, Germany, can be applied for an automatic regulation of temperature up to 2000° C. A thermo-couple connected with a galvanometer, simultaneously activates a relay, which opens or closes the gas or air valves of a furnace. For temperatures above 1250° C. a radiation pyrometer is generally employed instead of thermo-couple.—G.N.

(Current Literature Review continued on Page 20)

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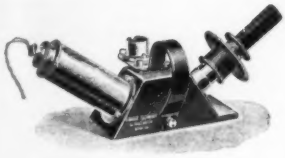

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CURRENT LITERATURE REVIEW

Experiments On the Compressive Strength of Refractory Bricks at Room Temperature (Gemeinschaftsversuch ueber Druckfestigkeit von Schamottesteinen bei Zimmertemperatur). Dr. Groothoff. Tonindustrie Zeitung, March 14, 1929, pp. 430-434.

This publication No. 16 of the Committee of the Bund deutscher Fabriken feuerfester Erzeugnisse, gives the testing apparatus and the results of large scale tests carried with the object of determining the compressive strength of refractory bricks at ordinary temperatures. Includes bibliography.—E.F.

Micro Analysis of Cement and Raw Materials (Die Kleinuntersuchung von Zement und Zementrohstoffen). H. Kuehl. Tonindustrie Zeitung, March 7, 1929, pp. 374-377.

Paper No. 27 of the Zementtechnisches Institut der Technischen Hochschule, Berlin, reviews the apparatus for analysis of cement and raw materials.—E.F.

Measurements with the Aid of Liquid Helium (Messungen mit Hilfe von fluessigem Helium). W. Meissner. Zeitschrift fuer die gesamte Kaelteindustrie, April 1929, pp. 62-68.

Apparatus, mainly vacuum calorimeters, for the determinations of resistances of metals at low temperatures by means of liquid helium in the new cryogen laboratory of the Physikalisch-Technische Reichsanstalt.—E.F.

Investigations of Filter Material and Tissues in Regard to Permeability to Air (Untersuchungen ueber die Luftdurchlaessigkeit von Filterstoffen und Geweben). W. Sell. Rauch und Staub, Feb. 1929, pp. 19-21.

Theoretical derivations, apparatus and determinations.—E.F.

Recording Speedometer for Automobiles (Geschwindigkeitsmesser fuer Kraftfahrzeuge mit selbsttaetig sich aufzeichnendem Fahrtbild). A. Lion. Dinglers Polytechnisches Journal, May 1929, pp. 102-103.

The speed is automatically recorded on an annular color-strip giving the speed curve of say the last 10 miles or any other distance. Due to severe speed restrictions in Germany and increasing number of accidents, the new instrument intends to prove or disprove reckless driving.—E.F.

Apparatus for Automatic Interruption of Distillations (Apparat zur selbsttaetigen Unterbrechung von Destillationen). G. Rankoff. Chemische Fabrik, Sept. 4, 1929, pp. 401.

A float actuates an electromagnet which turns off the gas or electricity.—E.F.

X-Ray Examination of Glass (Roentgenuntersuchung fuer Glas). M. Knopff. Glas und Apparat, April 21, 1929, pp. 74.

Author recalls a statement of Roentgen concerning the adaptability of X-rays for the examination of glass.—E.F.

Recent Gas Analytic Methods (Neue gasanalytische Methoden). H. Ebert. Gas und Wasserfach, April 13, 1929, pp. 344-347.

Anticipating the historical development of gas analytic methods, the author discusses the recent steps to replace the volumetric gas absorption method.—E.F.

The Dresden Method of Checking Water Meters and the Location of Water Losses in Private Lines (Das Dresdener Verfahren der oertlichen Wassermesser Untersuchungen und die Aufsuchung von Wasserverlusten in den Privatleitungsanlagen). Director Vollmar & Amtsbaurat Baese. Gas und Wasserfach, April 13, 1929, pp. 350-354.

Illustrated article gives the instruments and methods of water measurements with the object of pointing out losses.—E.F.

Determination of Small Amounts of Hydrogen Sulfide in Gases (Die Bestimmung geringer Mengen Schwefelwasserstoff in Gasen). H. Bach. Gas und Wasserfach, Feb. 16, 1929, pp. 154-155.

Apparatus and determinations are described.—E.F.

The Influence of the Voltage Curves Upon the Image in X-Ray Technique (Der Einfluss der Spannungskurven auf die Bildgebung in der Roentgentechnik). G. Spiegler. Elektrotechnik und Machinenbau, April 21, 1929, pp. 342-345.

The superiority of the rotating rectifier and the constant voltage apparatus in comparison with the four tube apparatus providing the same peak values of voltage and equal tube currents are used, has been proved especially in case of more pronounced filtering. The curves for the screen light intensities as obtained with the different apparatus under various filtering conditions are given. Comparison of the smaller degree of brightness is made and the influence upon load investigated.—E.F.

Practical Applications of X-Rays for the Examination of Material According to the Absorption Method (Praktische Anwendungsgebiete der Roentgenuntersuchung von Werkstoffen nach der Absorptionsmethode). E. Petertiel. Elektrotechnik und Machinenbau, April 21, 1929, pp. 345-348.

Advantages of radiographic investigations of material are considered and a large number of successful applications for daily use are illustrated.—E.F.

A Logarithmic Annular "Slide Rule" for Stereophotogrametric Purposes (Ein logarithmischer Kreisrechenschieber fuer stereophotogrammetrische Zwecke). H. Dock. Bildmessung und Luftbildwesen, June 1929, pp. 95-97.

The use of the illustrated slide rule is demonstrated.—E.F.

New Patented Gas and Water Meters (Neue patentierte Gas-und Wassermesser). Dr. Kausch. Wasser und Gas, February 1, 1929, pp. 504-509.

The author reviews the 31 most important modifications and new devices for measurement of water and gas patented in 1928 in Germany.—E.F.

Which System and What Material Must Be Preferred When Installing a Current Meter? (Welchem System und welchem Material ist bei Beschaffung von Fluegelradmessern der Vorzug zu geben?) C. J. Burkhardt. Wasser und Gas, May 1, 1929, pp. 76-79.

The author critically discusses the customary devices for measuring water.—E.F.

(Current Literature Review continued on Page 21)

CURRENT LITERATURE REVIEW

On the **Definition and Determination of Calorific Power of Gases** (Einiges ueber Definition und Bestimmung des Heizwertes von Gasen). Dr. Dommer. Gas und Wasserfach, Feb. 23, 1929, pp. 180-182.

Definition of Koal, influnce of barometer, temperature and water vapor on lower heating value, hand calorimeter of Junkers, Dommer, Strache-Loeffler, recording calorimeters including automatic and hand calorimeters.—E.F.

How to Prevent Damaging the Diamond Testing Point of the Rockwell Hardness Tester (Wie erreiche ich bei Verwendung des Rockwell Haerteprueefers eine groestmoegliche Schonung der Diamant-Pruefspitze). Rueter. Glasers Annalen, June 15, 1929, pp. 175-178.

Anticipating the advantages of the Rockwell Testing Machine, the author gives the causes for damaging the diamond testing point and suggests various devices for saving the diamond to increase its life.—E.F.

New Designs and Standardization of Laboratory Apparatus of the Dechema (Neue Normblattentwuerfe von Laboratoriumsgeraeten der Dechema). Deutsche Gesellschaft fuer chemisches Apparatewesen. Glas und Apparat, June 16, 1929, pp. 117; July 14, 1929, pp. 137.

The proposed standards for burettes according to Bunte, Drehschmidt and Hempel.—E.F.

Investigations of the Tensile Strength of Cement Mortar and Concrete (Untersuchungen ueber die Zugfestigkeit von Zementmoertel und Beton). H. Ohlsen. Beton und Eisen, June 5, 1929, pp. 204-209; June 20, 1929, pp. 218-220.

Paper presented at the 32nd General Meeting of the Deutscher Beton Verein, March 1929, Berlin, deals with the strength of various cements determined as bending tensile strength with beams of 15x15x70 cm dimensions and 65 cm span stressed by bending in the middle with increasing load.—E.F.

Expansion and Tensile Strength Determinations of Refractory Material for Glass Plants (Ausdehnungs-und Zugfestigkeitsbestimmungen an feuerfesten Baustoffen fuer Glashuetten). J. F. Hyslop, N. C. Biggs and R. F. Proktor. Glastechnische Berichte, Jan. 1929, pp. 561-571.

The apparatus developed by the Research Laboratory of the General Electric Co., Ltd., Wembley, and its application is outlined.—E.F.

Scales and Scales Contrivances for Mixtures (Wagen und Waegevorrichtungen fuer Mischungen). W. Felgentraeger. Glastechnische Berichte, May 1929, pp. 45-48.

Paper presented at the 10th Glastechnische Tagung, Berlin, reviews the modern scales and discusses the most favorable applications.—E.F.

The Geo-physical Exploration Methods with Alternating Current According to the Probe Method (Die geo-elektrischen Untersuchungsmethoden mit Wechselstrom nach der Sondenmethode). P. Huelsenbeck and W. Geyger. Montanistisch Rundschau, Aug. 1, 1929, pp. 289-295.

The authors explain with the aid of 12 figures the theoretical principles concerning the application of alternating current for geo-physical methods.—E.F.

Measuring Apparatus for Investigations in Regard to Losses and Control of Compressed Air Economy in Mines (Anwendung der Messtechnik fuer die Verlustquellenforschung und Arbeitsueberwachung in der Pressluftwirtschaft untertage). F. Brinkmann. Glueckauf, Jan. 5, 1929, pp. 7-16; Jan. 12, 1929, pp. 41-49; Jan. 19, 1929, pp. 73-78.

A comprehensive, abundantly illustrated survey to prove the useful application of measuring instruments for greater economic application of compressed air in mines.—E.F.

Determination of Combustion Heat by Means of the Junkers Calorimeter (Die Bestimmung der Verbrennungswaerme mit dem Junkers Kalorimeter). W. Wunsch. Glueckauf, July 27, 1929, pp. 1021-1028.

In determinations with the Junkers calorimeter, the dependence of the determined combustion heat on the temperature and moisture content of the gases are pointed out and the numerical values for various gases are given. A relationship between determined combustion heat and the addition of heat into the calorimeter is proved and isothermic accomplishment of determinations is urged. The author proposes determinations of combustion heat only under complete water vapor saturation of gas and air and the inclusion of a corresponding correction, the necessary evaluation of which is given. A suitable arrangement for accomplishing the determination as an isothermic process under saturated water pressure is described. Influence, determination and calculation of radiation of the calorimetric process are stated. The author concludes with critical consideration of the definition and determination of the lower calorific power.—E.F.

Determination of the Aging Tendency of Insulation and Steam Turbine Oils (Die Bestimmung der Alterungsneigung von Isolier-und Dampfturbinenoelen). A. Baader. Petroleum, Feb. 13, 1929, pp. 235-243; Feb. 27, 1929, pp. 279-283.

The paper presented at the 41st General Meeting of the Verein deutscher Chemiker, Dresden, fully outlines the deterioration of oils due to oxidation in contact mainly with metals and illustrates and explains a new patented apparatus for the more satisfactory determination of aging.—E.F.

Contribution to the Question of the Direct Exploration of Petroleum Deposits with Electrical Methods (Zur Streitfrage der direkten Auffindung von Erdoellagerstaetten mit Hilfe von elektrischen Verfahren). H. Hunkel. Petroleum, March 6, 1929, pp. 293-308.

The applicability of electrical methods for the detection of petroleum deposits is denied on account of its low conductivity.—E.F.

Determination of the Softening Point of Pitches and Asphalts (Ueber die Bestimmung des Erweichungspunktes von Pechen und Asphalten). A. Spilker. Petroleum, June 19, 1929, pp. 835-836.

A modification of the Kraemer-Sarnow method for the determination of the softening point of asphalts, etc., to eliminate the mercury formerly used on account of its poisonousness. Determinations by both methods are given.—E.F.

(Current Literature Review continued on Page 23)

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CURRENT LITERATURE REVIEW

A Simple Optical Pyrometer for Temperature Measurements Between 950 and 2000° C. (Ein einfaches optisches Pyrometer zur Temperaturmessung zwischen 950 und 2000° C.). G. Naeser. Zeitschrift fuer Metallkunde, Aug. 1929, p. 273.

The uncertainness of former measurements due to the dependence of the emitted total radiation on the accidental surface conditions is eliminated. The new optical pyrometer uses for the determination of temperature the distribution of energy, i.e., the color of the radiation. A comparison light source is unnecessary, by comparing two determined colors of the radiation spectrum. The light of the radiator passes through a prismatic light filter which transmits exclusively red and green and absorbs all the other colors. The resulting white mixed color must be located on the prism by means of a sliding diaphragm and the temperature can be read off directly. The following advantages are claimed for the instrument: Accuracy of two per cent, and one per cent after experience, about the size of a watch.—E.F.

Abolishment of the Beaumé Hydrometer (Abschaffung der Beauméspindel). Th. Wallis. Chemische Fabrik, March 20, 1929, pp. 125-136.

The present paper, summing up the work of a committee of the I. G. Farbenindustrie, proposes a satisfactory standard hydrometer based on specific gravity for testing solutions with a hydrometer.—E.F.

Bi-Metal (Bimetall). W. Rohn. Zeitschrift fuer Metallkunde, Aug. 1929, pp. 263-264.

The author describes the 3 most important measuring instruments, for the determination of the properties of bi-metals. Up to 300° C. the bi-metal fixed at one end is heated in an oil bath. The deflection is measured by means of a micrometer screw, which short-circuits a bell circuit. The forces necessary for bending back the metal can also be determined. For comparing measurements in daily work an electrical device is preferred. The bi-metal containing a thermo couple inside, is wrapped with resistance wire and the electric current flowing can easily be determined. In a third design the deflection is transmitted to a pointer. The heating current is sent directly through the test piece.—E.F.

A Simple Sedimentation Apparatus (Ein einfacher Sedimentationsapparat). H. Kuchl Tonindustrie Zeitung, Aug. 29, 1929, pp. 1247-1250.

The new apparatus for the determination of particle size below 0.06 mm is designed to meet the increased demands of clay and cement industry to replace the troublesome and limited screening method. The patented apparatus is based on Stoke's sedimentation principle. The material is elutriated in alcohol in a cylinder of 1.42 m length. The new device involved in the apparatus is an electric heating system with the object of giving a lower specific gravity to the suspension of cement in alcohol in comparison with the pure sedimentation liquid alcohol, so that a gradient in the liquid column is attained. The latter is gradually tapped into glass bottles placed upon a rotating table. The paper includes the results of some determinations.—E.F.

Sieve Screens and Sifting Results (Siebgewebe und Siebergebnisse). Hans Hecht. Tonindustrie Zeitung, Sept. 2, 1929, pp. 1265-1268.

The author reports on the recently introduced German standards for screens the tolerances of which correspond to the American ASTM Standards. The checking of the manufactured screens is carried out with an apparatus developed in the Staatliches Materialpruefungsamt Berlin-Dahlem. The paper gives the results of experiments on a large scale with sieves which do not correspond to the standards and which exhibited very indefinite results proving the necessity of standardization.—E.F.

Testing the Fire Proofness of Building Material (Die Pruefung der Feuersicherheit von Baustoffen). R. Schlyter. Tonindustrie Zeitung, Aug. 19, 1929, pp. 1183-1185.

Due to continuous requests from industry, the Swedish Material Testing Laboratory, Stockholm, developed methods for testing the fire-proofness of building materials which are described and illustrated in the paper.—E.F.

Concerning the Question of Determining the Finest Constituents in Cement (Zur Frage der Bestimmung der feinsten Anteile im Zement). H. W. Gonell. Tonindustrie Zeitung, Aug. 1, 1929, pp. 1105-1107.

Critically discussing the Dickerson Apparatus, the author explains his own apparatus for determining the finest constituents by means of a wind-sifter instead of wet sedimentation or elutriation. A comparison of the results obtained from both methods is given.—E.F.

Tipping Wagons with Weighing Apparatus (Muldenkipper mit Waegevorrichtung). Dipl. Ing. von Meng. Tonindustrie Zeitung, May 27, 1929, pp. 748-749.

The inaccuracy of conventional methods for making up mixture ratios by volume is criticized and a new wagon with weighing apparatus is described. The range of weighing amounts to 500 kg.—E.F.

Determination of Grain Size by Means of Pipette Analysis (Korngroessenbestimmung mit Pipettenanalyse). M. Koehn. Tonindustrie Zeitung, May 23, 1929, pp. 729-731.

The apparatus based on Stoke's formula is illustrated and explained and the accomplishment of measurements as well as some results of practical determinations are given.—E.F.

Contribution to the Determination of Corrosion Resistance of Refractory Materials (Beitrag zur Bestimmung der Korrosionsfachigkeit feuerfester Materialien). W. Neimann. Tonindustrie Zeitung, March 25, 1929, pp. 484.

The paper deals with the resistance of refractory material against corrosive attack of slags and the determination of the latter.—E.F.

Dickson's Apparatus for Determining the Grain Size of Cement (Der Dickson Apparat zur Bestimmung der feinen Anteile im Portlandzement). H. Richarz. Tonindustrie Zeitung, June 4, 1929, pp. 815-816.

Progress in fine grinding technique called for more delicate apparatus to determine grain size. The Dickson Elutriator, developed in England, designed to meet these requirements, is illustrated and described in the present paper which also includes practical results.—E.F.

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(Buyers' Guide continued on Page 27)

CURRENT LITERATURE REVIEW

The A E G Testing Method for Deep-Drawing. G. R. Fischer. AEG-Mitteilungen, July 1929, pp. 483-486.

The author describes a testing apparatus which permits continuously following the stresses during deep-drawing operations of metals. The suitability of the material is judged by the facility with which a normal smooth-walled pot can be drawn from a round disc under shop conditions. The procedure in connection with shop practice is described.

Essentials for Accurate Gaging of Compressible Material. Roy W. Brown. Rubber Age, July 25, 1929, pp. 431-433.

Variables affecting the accurate thickness measurement of compressible sheet materials such as fabric and rubber stock are indicated as: 1. Linear accuracy of the micrometer. 2. Pressure exerted by the micrometer foot. 3. Size of the micrometer foot. 4. Friction in the micrometer mechanism. A unit area foot pressure of (70-3 gram per sq. cm.) 1 lb. per sq. in. has been found satisfactory. Friction in the micrometer mechanism is shown to limit the minimum foot pressure to approximately (199.5 grams) .44 lbs., hence a (1.906 cms.) ¾" diameter circular foot, or equivalent, is required on present available mechanical gages. Methods of meeting the above fundamental requirements are indicated for optical and magnetic gages. Limiting factors in the accuracy securable by the use of dielectric gages are discussed. The necessity for standardized practices is so apparent as to commend consideration of all concerned.

The Caesium-Magnesium Photocell. V. Zworykin and E. D. Wilson. Jl. Opt. Soc., Aug. 1929, pp. 81-89.

The values of the work functions of the alkali metals and their color-sensitivity curves indicate definitely that caesium is the most favorable material for use in photocells. The practical difficulties of handling caesium metal have been overcome in the caesium-magnesium cell, in which a freshly evaporated coating of magnesium not only binds an invisible layer of caesium to the walls of the cell, but also provides an electrical connection with the cathode terminal. Average color-sensitivity curves are given for more than twenty cells. They show that the maximum sensitivity lies at about 4850A, as compared with 4400A for pure potassium, 5390A for pure caesium, and 5560A for the human eye. The photoelectric properties of the cell are detailed by means of response-voltage curves, response illumination curves and illumination limit curves. The maximum response for vacuum type cells is about 2 microamperes per lumen, and for gas-filed cells about 25 microamperes per lumen under normal operating conditions. Several commercial applications are described. Further development work is not in progress.

Some Experimental Methods and Apparatus for Determining the Stresses in Bridges and Framed Structures. Ernest George Coker. Paper No. 4733. Institution of Civil Engineers, 1929.

In recent years there has been a marked increase in the number of bridges and framed structures in which the stress-distributions are not determinate from purely statical considerations, and are only ascertainable by laborious mathematical analysis. To avoid this labor, and also the assumptions usually made to simplify calculations, models have been frequently used to ascertain experimentally the stress at any point of a structure. In most of these models linear measurements of the deformations of circles on plane surfaces of models have been made, which increase in accuracy as the diameter of the circle decreases, provided the instrumental means are sufficiently accurate. The author advocates a different method, namely, lateral measurement of the change of thickness due to load, which involves no approximation beyond the assumption that the stress is uniform across the thickness at any point, and is especially useful at the edges of steel members, where the maximum stresses are usually found. At other points mechanical measurements on the actual member combined with optical measurements on models are suggested, or, alternatively, on the latter alone.

Apparatus for Testing the Dilution of Lubricating Oil in Automobile and Airplane Motors (Apparat zur Pruefung der Schmieroelverduennung in Automobil und Flugzeugmotoren). H. Kiemstedt. Chemiker Zeitung, June 12, 1929, p. 495.

The various causes of the deterioration of lubricating oil are given and the consequences mentioned. The new apparatus, which is based on the method of steam distillation and its operation are described in detail.—E.F.

The Quartz Analysis Lamp, Original Hanau, in the Laboratory of Oil Plants (Die Analysen Quarz Lampe, Original Hanau, im Laboratorium der Oelfabriken). A. Wagner. Chemiker Zeitung, May 22, 1929, pp. 398-399.

The paper outlines the application of the quartz analysis lamp for examination of oil, glycerines, resins, coatings, etc., and the luminescence effect of some forty materials are assembled in a table.—E.F.

The Accuracy of Vernier Readings of Finely Divided Circular Scales (Die Genauigkeit der Ablesung an einem Kreis bei feinen Kreisteilungen). K. Luedemann. Zs. Instrument, May 1929, pp. 238-248.

After reviewing previous investigations along these lines, the author presents his own observations concerning the determination of accuracy of vernier-reading.—E.F.

An Improved Balloon Theodolite (Ein verbesserter Ballontheodolit). Dr. Koelzer. Zs. Instrument, June 1929, pp. 292-295.

The author explains the theodolite of the Sprenger Co., Berlin, and fully describes the new improvements.—E.F.

Curve Measuring Instruments of Pressel and Riefler (Kurvenmesser von Pressel und Riefler). K. Pressel. Zs. Instrument, June 1929, pp. 292-295.

By means of 8 illustrations, the author gives a detailed description of an improved instrument for the determination of curves based on the principle of the planimeter. The results of two actual measurements are given in a table.—E.F.

A New Conimeter (Ein neues Konimeter). E. Loewe. Zs. Instrument, June 1929, pp. 296-298.

The new conimeter, which is used for the determination of dust in rooms, mines, mills, etc., is described and illustrated. The apparatus, which precipitates the dust by means of a pneumatic device upon a glass plate examined by a microscope, is constructed by the Carl Zeiss, Jena. It permits taking 180 samples in a row.—E.F.

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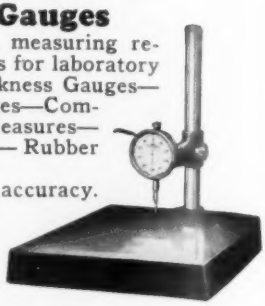

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B. W. ST. CLAIR. INSTRUMENTS, Vol. 2, No. 11, November, 1929, pp. 371-377, 12 figs.

The introduction briefly reviews the more salient points of frequency meter design. A number of circuits are discussed, and their general features given. The construction of an armature is shown.

THE WATER CURRENT METER.

PAUL E. HOFF. INSTRUMENTS, Vol. 2, No. 11, November, 1929, pp. 379-380.

The forces exerted by the stream upon the current meter are considered. The rating of meters is considered. The importance of constructing meters to be least flow obstructing is pointed out.

MEASUREMENT OF AIR FLOW.

E. OWER. INSTRUMENTS, Vol. 2, No. 11, November, 1929, pp. 379-395, 11 figs.

Chapter III. The Design of Pitot and Static Tubes. This is the second installment of a series on the measurement of air flow.

MEASUREMENTS—INDUSTRIAL AND SCIENTIFIC.

DR. WALTER BLOCK. INSTRUMENTS, Vol. 2, No. 11, November, 1929, pp. 397-406, 2 figs.

This is the third installment of a series. The original work is a German book entitled "Messen und Waegen." The Metric System and the International Meter Treaty is considered.

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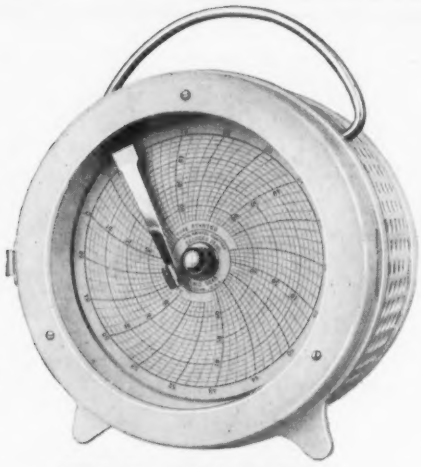

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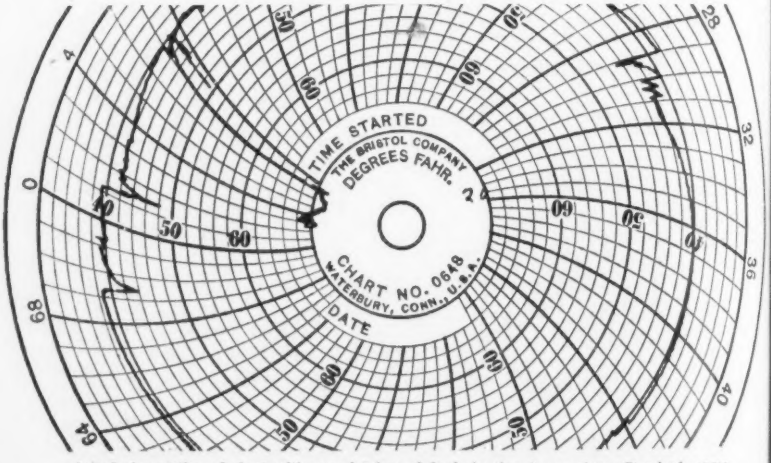

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